Multi Part Integration Concepts for Innovative BEV Body Architecture

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ABSTRACT
Automotive manufacturers are moving rapidly towards producing high-volume battery-electric-vehicles (BEV) in an effort towards a clean and sustainable future. Electrification introduces flexibility into vehicle architecture by adapting to an updated powertrain while reimagining the vehicle structure. Alternative materials like Aluminum, Magnesium and composites are good choices for low volumes but are not ideal for high production volumes due to multiple factors like cost of production, recyclability and carbon footprint. Leveraging economies of scale is critical for cost optimization and therefore long-term business viability. To optimize enterprise cost, OEMs are simplifying assembly by reducing assembly steps by designing so-called Mega Structures. Our steel laser welded Multi Part Integration™ (MPI) concepts¹ are excellent solutions to meet these challenges.

Laser welded blank (LWB) technology is a proven solution enabling performance improvement, part consolidation, and weight optimization in vehicles. Additionally, cost improvement, modularity, and sustainable steel use make LWBs an ideal solution to BEV architectural challenges. ArcelorMittal Tailored Blanks (AMTB) showcases our next generation of Multi Part Integration (MPI) battery pack concept in steel that enable the re-designing of the vehicle architecture surrounding the passenger and battery space. Our design concept enables cell-to-body integration, which can make the battery pack modular with reduced part count by potentially eliminating the floor pan and provide additional rigidity to the cabin space. The concept has been developed to minimize the total part count and assembly operations in a Body-In-White (BIW). A novel battery pack design using MPIs with an integrated floor reinforcement design simplifies the battery structure construction while managing crash loads using the MPI designs.

Our presentation demonstrates steel-based architectures using MPI designs are key enablers in weight reduction, cost improvement, performance optimization, and reducing assembly complexity, cost and time while lowering CO₂ emissions of future BEV designs.

INTRODUCTION

Project Background
S-in motion® is a set of steel solutions developed by ArcelorMittal² for carmakers who wish to create lighter, safer, and more environmentally friendly vehicles. AMTB created the AMTB BEV design by modifying the S-in motion® Mid-size SUV to develop LWB solutions on a BEV architecture. AMTB had developed a steel battery pack structure using Press Hardened Steel (PHS) LWB designs called Battery Rings. The Battery Ring structure focused on part commonality with Internal combustion engine (ICE) architectures which allowed OEMs to transition from ICE to BEV architectures with minimal changeovers in assembly processes. This design was validated in a 2021 study³ by AMTB. With the evolution of LWBs and body architectures as a part of the electrification effort in the automotive industry, we have continued to develop the AMTB BEV design to implement newer and more innovative MPI solutions on the BIW and battery pack architectures to develop the latest design...
called the New BEV (NBEV). The NBEV architecture using MPIs enables OEMs to leverage conventional BIW assembly processes while creating a simplified and modular assembly.

**Architectural modifications**
To create the NBEV architecture, the cabin floor and seat reinforcements are removed from the BIW assembly (Fig. 1).

![Figure 1. Architectural Modifications](image)

The battery pack design in the AMTB BEV is updated to a PHS upper battery cover and lower battery tub structure comprised of MPI designs. The Floor cross members are mounted on the battery pack which also provide extra safety and rigidity to the battery pack structure (Fig. 2). This structure also replaces the mid-underbody components in the AMTB BEV design. The internal structure and battery modules in the battery pack are retained in this update.

![Figure 2. Parts consolidated from AMTB BEV to NBEV](image)

The BIW is reinforced along the Sill with updated roll-formed structures to improve the rigidity of the BIW underbody. This updated BIW and battery pack structure helps streamline the assembly process due to part consolidation. This can also help reduce the assembly tooling and investment as described in the “Assembly benefits” sub-section. The modular nature of the assembly process can also allow interchangeability of sub-assemblies between different vehicle segments (i.e., wheel lengths, wheelbase, platforms...) and minimize the cost and floor space needed for a wider range, scope of vehicle designs for lean manufacturing of complete vehicles.

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MPI BENEFITS

**Weight Reduction**
Using the new body architecture, the NBEV design saves 14.9 kg compared to the AMTB BEV architecture with equivalent crash performance for all safety loadcases in our study. Use of PHS MPI designs in areas critical to crash performance help optimize the gauge/grade distribution and reduce weight.

**Part Consolidation**
The NBEV structural battery pack design replaces multiple components in the mid-underbody of the vehicle and the battery pack enclosures into a hot stamped lower battery tub MPI, a hot stamped upper battery cover with an integrated floor reinforcement mounted on the lid. These 3 MPIs consolidate a total of 16 components from the AMTB BEV design. Lower part count using MPIs also enables additional benefits like minimized assembly operations, logistics, organizational structural costs, and lower build complexity for the entire vehicle.

**Material Utilization**
By optimizing the weld seam positions, the MPI designs on the NBEV architecture help improve the overall Material utilization by 4% of the components. The gross steel usage in production of the NBEV MPI components is 33 kgs lower compared to production of equivalent AMTB BEV components. Lower steel usage in turn leads to lower CO₂ emissions during the manufacturing phase of the vehicle.

**Assembly benefits**
The part consolidation helps eliminate assembly operations and logistics involved in assembly. This allows the total assembly investment to be reduced by up to 34% and the total assembly floor footprint is reduced by 29% (Fig. 3). This can allow new OEMs to implement this design with a smaller capital investment and maximize use of the available floor space for additional equipment.

![Figure 3. Assembly floor space and Investment comparison](image)

**Sustainability**
MPIs allow improved material utilization during the manufacturing process which results in lower emissions. Laser welding processes are relatively more efficient thus reducing the carbon footprint in the part joining. The NBEV design helps save over 15% emissions in the manufacturing process compared to the AMTB BEV design with a total of 45 kg CO₂ eq. emissions reduced. The NBEV design using MPIs also enables weight savings in the vehicle. A lighter vehicle leads to a smaller carbon footprint during vehicle use by 83 kg CO₂ eq. emissions. Use phase emissions are calculated based on estimated US charging grid emissions for an avg. vehicle lifecycle of 200,000 kms. For an estimated yearly production volume of 200,000 vehicles, implementing the NBEV architecture saves a total of 25.5 ktonnes of CO₂ eq. emissions yearly combining the production and use phase emissions.
PERFORMANCE

Crash safety
The NBEV architecture was validated for all major IIHS, NHTSA & FMVSS crash safety loadcases – SORB, Side Impact and 50th Pole Impact, Frontal impact & Rear Impact. As seen in Fig. 5, 6 and 7, the design performs safely for the 3 most severe loadcases with no intrusion in the battery modules. Fig. 8 shows the internal energy distribution among the different subsystems in side impact loadcases and the contribution of the Battery pack in each crash. Other non-safety attributes (NVH, stiffness, manufacturability…) will be comparable to the AMTB BEV solution.
Figure 6. Side Impact Intrusion comparison

Figure 7. 50th Pole Impact: Cross sectional view of NBEV Sill & Battery structure crushing
CONCLUSIONS

In conclusion, the NBEV structural battery pack design using MPIs is an innovative concept which allows re-imagining the BIW and battery pack construction process while helping reduce weight, assembly processes & costs and the overall carbon footprint of the vehicle through the production and use phase. The concept designs are validated for forming feasibility and crash safety and allow consolidation of 16 mid-underbody and battery pack components into 3 MPIs. The part consolidation results in improved efficiency in the assembly process and makes the vehicle design more sustainable with a minimized carbon footprint. The sealing of the battery pack and cabin space still needs addressing but can be added to the scope of the study and achieved with the availability of resources. The MPI structural battery pack is a tested LWB concept which can allow OEMs to optimize cost, weight, performance and sustainability of future vehicles.

REFERENCES

1. What is ArcelorMittal Multi Part Integration™ (MPI)?

