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Development of Advanced Technologies for Further Functional Integration of Components

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This paper presents technologies to further integrated automotive body components using hot-stamped steel sheet. Driven by stricter regulations and BEV adoption, body structures must improve crash performance while reducing mass, cost, and life cycle GHG emissions. Compared with aluminum-intensive multi-part designs and large die-castings that may require high capital investment and can limit repairability and production flexibility, steel-based press forming and hot stamping provide a scalable path to part consolidation while keeping established manufacturing infrastructure.

Figure 1 illustrates steel-sheet integration from small car-body parts (TWB/patchwork) to large modules enabled by hot stamping (e.g., door rings, rear modules, floor frames). Key differentiators of this approach are: Stepwise scalability aligned with platform volume and investment constraints, high strength with tailored local performance using sheet-based grade/thickness design, and compatibility with existing press/hot-stamp production and practical repairability.

As a large-scale example, an integrated rear underbody module was developed using Al–Si coated hot-stamping steel with tailored strength distribution. A 2.0 GPa-class steel was applied to front-side regions to maintain load paths and suppress deformation, while 1.0 GPa-class steel was used in rear-side members to promote stable axial crushing for energy absorption; 1.5 GPa-class steel was used for cross members, rear floor panels, and wheelhouses. These grades were selectively combined via TWB technology to optimize local function without increasing part count.

Crash performance was verified by dynamic axial crushing tests of 1.0 GPa-class hat members and a full-module drop-weight impact test equivalent to rear collision. The rear-side members showed controlled axial crushing while front-side regions remained undeformed, with no fractures in TWB joints or panels. LS-DYNA simulations reproduced the deformation mode and load response with good agreement.

To enable complex integrated geometries, forming and joining technologies were developed to extend TWB applicability. For spot-welded TWBs, weld placement/timing was customized to control material flow and reduce cracking and wrinkling, and a small corner-radius forming method was set up for space-constrained joints. For Al–Si coated hot-stamping steel, a laser-welded TWB process was developed with local coating removal near weld edges to suppress Al enrichment, resulting in uniform hardness and robust joints after hot stamping.

The results show that hot-stamped steel sheet enables scalable integration from small car-body parts to large modules, supported by confirmed tailored-strength design and robust TWB joints. This strategy offers a competitive alternative to aluminum architecture by reducing dependence on large casting investments while improving repairability and production flexibility, with potential benefits in mass, cost, and life cycle GHG emissions.

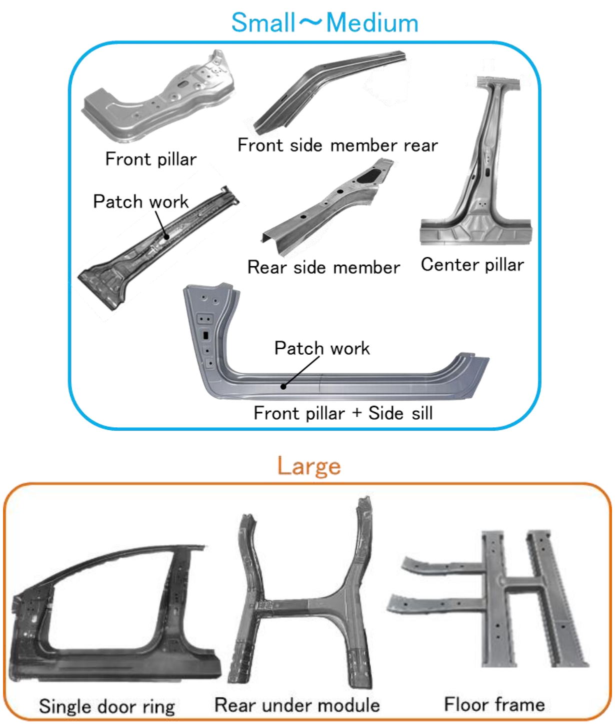

Fig.1 Examples of the integrated components