講演番号	038

文献番号	20226038

Development of Cell to Pack Structure for Downsizing of Battery Pack

-Battery Restraining with Die-cast Aluminum Battery Pack Case-

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KEY WORDS: **EV and HV systems, Battery technology,** Cell to pack, Battery restraint [A3]

Amid concerns over global warming and the depletion of oil resources, there is an urgent need to further promote xEVs in order to achieve carbon neutrality. Downsizing of battery pack, a component of the xEV system, can improve vehicle product appeal such as exterior design or interior space size, expand the potential of sharing same unit among different vehicle models, and reduce mass and cost. The lithium-ion battery pack for previous-generation hybrid system shown in Fig.1 consists of an enclosure and battery modules, intermediate assembles consisting of multiple battery cells and components that bind the battery cells. This previous battery pack has a problem in that it is large in size due to the parts that bind the battery cells and the gap between the module and the housing.

The newly developed battery pack adopts a "cell-to-pack" structure in that the battery cells are directly housed in the pack case. Battery restraining function, which was previously performed by the battery module components, is integrated into the pack case as shown in Fig.1 along with the cooling air guiding function. This new structure has enabled 6% reduction in the battery pack size in the longitudinal direction.

The battery restraining is holding battery cells in compressed state by applying restraining load. The main purposes of battery restraining are to mechanically support the internal structure of the battery cell and to stabilize battery performance. Excessive or insufficient restraint load can cause cell damage or performance degradation, so the restraint load must be controlled within a specified range.

In the battery module of the previous battery pack, stacked plurality of battery cells and supports placed between the battery cells, were sandwiched between a pair of end plates connected with rods. In manufacturing process, the stack is compressed together with the end plates at the desired load, and the end plates are connected with rods. Only compression load is controlled, not dimension of the stack. Therefore, the restraint load is not affected by cell thickness tolerance.

On the other hand, in the manufacturing process of newly developed battery pack, the stack is compressed, inserted into the pack case, and released, as shown in Fig.2. In order to achieve this manufacturing process, compression load and stack dimension must be controlled within a desired range simultaneously. This requires a means to compensate for cell thickness tolerances and adjust stack dimensions. In addition, the pack case should not deform significantly when subjected to restraining load.

In this presentation, the following three technical ideas related to battery restraining with cell-to-pack structure are proposed: 1) Calculation model to determine stack dimensional tolerances and pack stiffness to ensure that the gap for inserting the stack into the pack case is maintained and that the restraining load is within the desired range shown in Fig.3. 2) Method of adjusting the stack length by adjusting the quantity ratio of two type of supporters different in thickness. 3) Pack case design using topology optimization to achieve both rigidity and weight reduction shown in Fig.4.

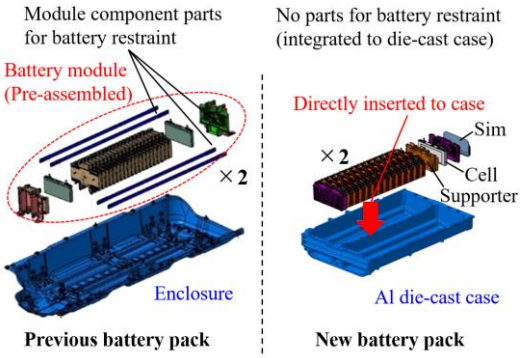

Fig.1 Comparison of structure

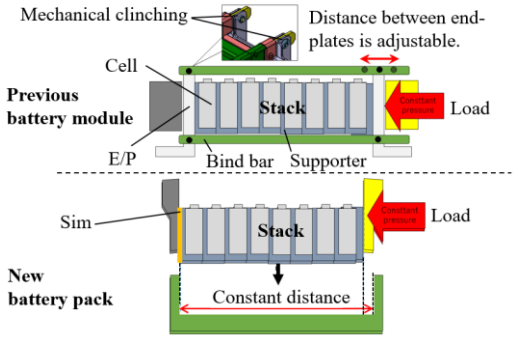

Fig.2 Comparison of manufacturing process

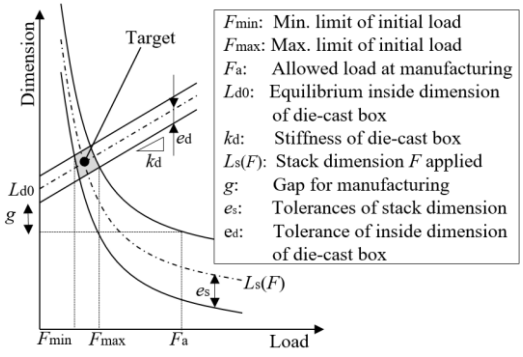

Fig.3 Diagram illustrating constraint of design variables

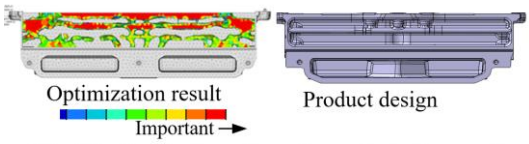

Fig.4 Product design referencing optimization result