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Development of High Power Battery for 100% Electric Drive Hybrid System by Heat Balance Optimization

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Nissan Motor has positioned the electrification and intelligentization of vehicles as two major pillars as a technological strategy to solve social issues such as resource depletion, environmental problems, traffic accidents, and traffic congestion. In order to promote electrification, we are expanding the application of 100% electric hybrid vehicles (e-POWER).

In installing e-POWER in a middle-class 4WD SUV, it was necessary to achieve not only higher power (approx. +30%) but also smaller size (approx. length -17%, volume -10%) compared to conventional model.(Fig. 1) Higher power and smaller size are in a trade-off relationship between heat generation and cooling capacity, respectively. In order to achieve the target thermal performance of the battery system, heat balance optimization including parameter studies was required.

The battery for e-POWER has 80 to 96 cells arranged in the pack, and the cooling fan rotation speed and allowable battery input/output power are controlled based on the highest cell temperature. Therefore, it is important to suppress the maximum cell temperature, and it is considered effective to equalize the cooling air volume to each cell as a countermeasure.On the other hand, the reduction of the cooling duct increases the air-flow velocity inside the duct. It causes un-uniform air distribution to each cell, and there is a problem that the cooling performance deteriorates.

Based on CFD analysis, it was found that the ΔP (inlet – outlet) on each cooling path between cells became uneven due to the pressure gradient increasing because of the narrowed exhaust duct. It was confirmed that this was the main factor in the deterioration of the air-flow distribution balance.(fig. 2) We focused on the effect of balancing the air distribution to each cell by increasing the pressure loss in the flow path between cells in the module.

By controlling the pressure loss balance in the channels between cells, the variation in distribution was improved from approx. ±70% to 20%. At the same time, the increase in the total pressure loss was kept to approx. +5%. As a result , the thermal resistance on the max. cell temperature is improved by approx. 10%.

We constructed a thermal balance optimization method by including parameter, and achieved both approx. +30% battery power and approx. -10% volume.

In addition, it is not an individual solution such as complicated flow path formation according to the shape of the battery pack, but a method that can be applied to general cell module and pack shapes. It will be useful in the development of further expanded applications.

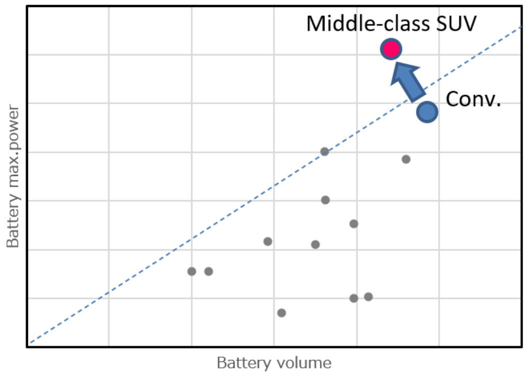

Fig.1 Target for battery volume and power

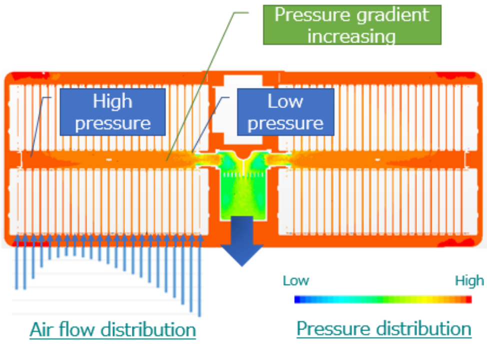

Fig.2 Pressure distribution and air-flow distribution in the battery pack

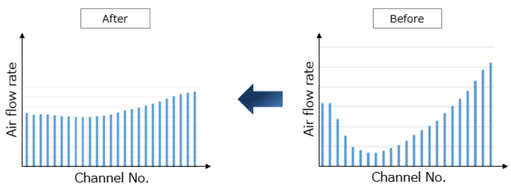

Fig.3 CFD analysis result of air-flow rate improvement