講演番号	173

Vehicle Electrification Effects on the Flow around a Vehicle and Vehicle Dynamics in Running

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KEY WORDS: **Vehicle dynamics, Aerodynamic performance, Driving stability, Electromagnetic interference** [D1]

A device focusing on the electrification state of a vehicle during driving has been proposed, and it is considered to influence the airflow around the vehicle and its dynamic behavior. The mechanism of this phenomenon is hypothesized as follows:
(1) Negative charges are generated through triboelectric charging caused by the separation of the tires from the road surface during driving.
(2) The vehicle body becomes negatively charged, forming an electric field between the body and the ground.
(3) Positive ions in the air are attracted toward the vehicle body.
(4) Accumulation, neutralization, and downstream convection of charges occur intermittently on the body surface.
(5) These processes induce flow fluctuations, which in turn affect vehicle dynamic performance.
To verify this hypothesis, the effect of performance enhancement devices - specifically, aluminum tape applied to the underbody - was investigated.

Through driving tests measuring vehicle dynamics, airflow (underbody pressure), and vehicle potential, the effects of the device were quantitatively confirmed as follows:
(a) The negative vehicle potential increased, while its fluctuation decreased.
(b) Low-frequency fluctuations in the underbody flow were reduced (Fig.1 Pfr, Prr), and pressure recovery was enhanced.
(c) Vertical motion became more responsive (Fig.1 Gzf, Gzr), accompanied by increased steering response (Fig.2 YR/TRQ, Gy/TRQ) and higher steering torque (Fig.2 TRQ/SA), indicating an influence on vehicle dynamic performance.

In a wind tunnel, the phenomenon was reproduced by applying a negative voltage to the vehicle and introducing positive air ions using an ionizer, confirming that electrostatic forces alter the airflow around the vehicle. As a device effect, it was confirmed that low-frequency flow fluctuations and turbulence were reduced, and that the flow tended to align along the vehicle floor.

Furthermore, as differences in the electrical properties of the vehicle due to the device, the charge transfer resistance from the body to the air and the electrostatic capacitance of the body were measured. Based on these results, a difference in charge retention capability was confirmed, and it was estimated that the vehicle potential during driving decreases accordingly.

Based on the above, the proposed hypothesis was partially validated in terms of the observed changes in phenomena. However, the mechanisms by which electrostatic forces modify the flow, as well as the behavior of charges—including their generation, transport pathways, and neutralization—remain unresolved. These issues will be addressed in future work.

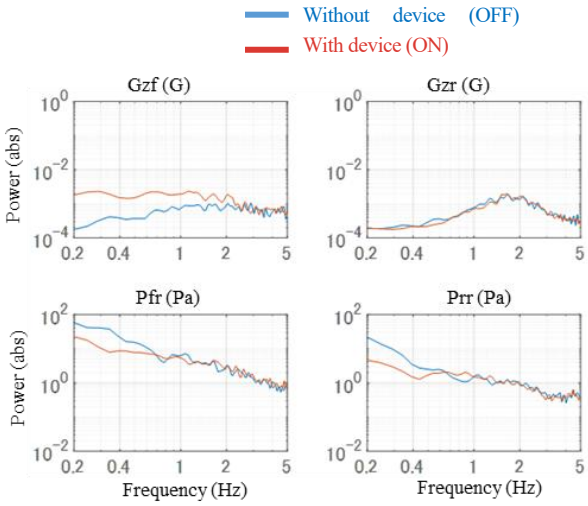

Fig.1 Comparison of power spectra of front, rear vertical acceleration and front, rear under-floor pressure (without/with device)

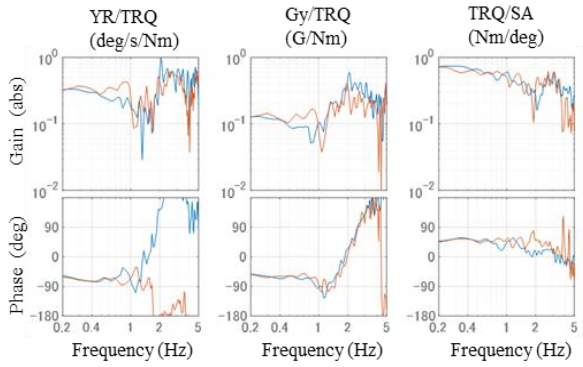

Fig.2 Comparison of steering response functions (without/with device)