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Real Road Test Reproduction Method of Battery Electric Vehicles in the Chassis Dynamometer Test Cell

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With the introduction of the Real Driving Emission (RDE) regulations in the last 5 years, there is a strong need to improve development efficiency in the automotive fields in order to become compliant. A particular challenge is the difficulty to repeatedly conduct Real Driving in the same condition. For this reason, the real road reproduction method in a chassis dynamometer has been getting a lot of attention. “Horiba Torque Matching Replication” (HTM Replication) method, previously demonstrated, makes it possible to reproduce Real Driving in the laboratory environment, by playing back the vehicle speed and pedal position on the dynamometer and driving robot.

In tandem with RDE regulations, the electrification of powertrains has been rapidly implemented as a means to not only reduce criteria emissions, but also as a measure to further reduce greenhouse gases (GHG). In particular, BEVs (Batttey Electric Vehicles), which do not generate GHGs while driving, are expected to contribute significantly to reducing GHGs.

Application of the HTM Replication method with BEV needs special consideration, because its performance against the pedal position may be sensitive depending on the vehicle conditions, such as SOC, external temperature or vehicle drive style setting. In this study, we first verify the accuracy of the HTM Replication method in the same vehicle condition with the road test. Following, we develop the “HORIBA Torque Matching Emulation” (HTM Emulation) method as a solution to generate the same dynamometer force with the road test whilst altering the vehicle condition against the road test. The HTM Emulation method is prescribed below:

(1) Based on the actual driving data, the HTM Replication method is applied to reproduce actual driving on the chassis dynamometer under the same vehicle condition with the road test.
(2) At this time, the driving force and vehicle speed generated by the vehicle are equivalent to those of actual driving on the road. Therefore, the dynamometer load obtained at this time will be defined as the target driving load.
(3) The target driving load obtained in (2) is reproduced with RLS control of the chassis dynamometer, by breaking down the target load into the road load, the inertia load and the gradient load.

The road grade profile used in (3) is expected to generate the same road force equivalent to that in (1) because the gradient value includes errors in the road load coefficient, the equivalent inertia weight, etc., while these errors are excluded from the gradient in the typical RLS method.

The HTM Replicaiton method shows close correlation with the road test by linear fit comparison, where both slope and R^2 is close to 1 in each pedal position and battery output. The HTM Emulation method is able to show better results than the typical RLS method in the same viewpoint. Fig.1 shows the transition of the battery energy consumption in each test. While the final integrated value of the typical RLS method is 11% different to that of the the road test, the error of the HTM Replication and the HTM Emulation method is much smaller at 2%.

Following, we changed the vehicle drive style setting in the HTM Emulation method. Fig.2 shows the pedal movement and dyno force in each test. Importantly, the HTM Emulation method is able to recreate same load as the HTM Repliction method, though the pedal movement is different in the changed drive style setting. Since the vehicle pedal control for the HTM Emulation method is a closed loop (to target speed, with gradient adaptations), it is able to generate the same dynamometer load as the HTM Replication method (considered equivalent to the road test) even if the vehicle condition is different from the road test.

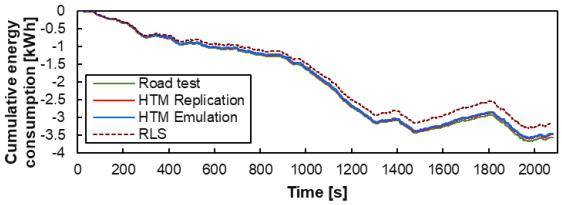

Fig.1 Road test vs. HTM Replication vs. HTM Emulation vs. RLS Cumulative energy consumption

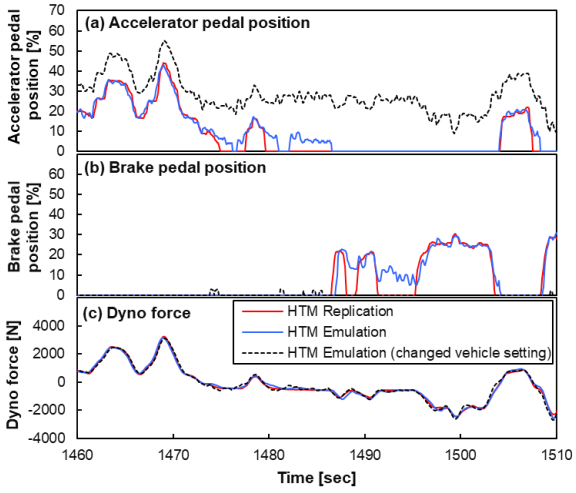

Fig.2 HTM Replication vs. HTM Emulation vs. HTM Emulation (changed vehicle setting) Accelerator pedal position (a), Brake pedal position (b) and Dyno force (c) (uphill to downhill section)