Study on BEV concept design based on data driven approach

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Abstract
This paper researched the Battery EV concept design based on the data driven approach. To determine the performance of BEV in the concept stage, a database was established through market research, and a data driven model was created to derive the target performance and specifications based on the database. To verify the results of the data driven model, the BEV model was generated, and the derived specifications were set. After that, the target performance was confirmed through simulation and detailed specifications were derived.

Keywords : BEV, e-Powertrain

1. Introduction
In the EV development process, there are difficulties in setting and designing system-level performance targets due to the multi-physics characteristics of EVs from a system-level perspective. In addition, the absence of a method for defining module/part target performance to meet system performance and requirements from a module/part level point of view is pointed out as a limitation of the prior art. Against this background, the need to establish a module/parts development strategy and concept considering the xEV system performance was required. In this paper, research was conducted with the goal of developing an xEV system based on system engineering technology. As a research method, based on the results of literature/market research, development concept establishment, model-based architecture, and concept specification design are carried out in the following order. In addition, as the performance of the developed vehicle, the vehicle performance that can be realized with the current e-Powertrain technology was set as a target, and an architecture using only mass-produced parts was implemented.

2. BEV Market Research
In this paper, a BEV database was established through market research. The surveyed vehicles were 37 sedans and 114 SUVs, and the survey items were battery capacity, motor output and torque, mileage, GVW, and wheelbase.

Figure 1. Battery Capacity vs Mileage
As a result of database analysis, recently mass-produced BEVs tend to be larger and higher in performance. Also, a high correlation between GVW, wheelbase, and battery capacity was confirmed.

3. Data Driven Modeling
To derive the target performance and specifications for the concept stage BEV design, a multi-linear regression model was constructed with the mileage, wheelbase, and vehicle weight as independent variables, battery capacity, motor torque, and motor power as dependent variables. Cross validation technique was used to improve accuracy.

Through the above process, the following multi-linear regression equations can be found. $Y_{predict}$ is the motor power, motor torque and battery capacity, and obtained the shown in Table 1.

$$Y_{predict} = \alpha_1 \cdot \text{wheelbase} + \alpha_2 \cdot \text{Range} + \alpha_3 \cdot \text{GVW} + \beta$$

Due to the distribution of data in the database, different results are obtained each time the process is performed. To obtain more reliable results, the above process was repeated 10,000 times to collect data, and the average value was set as the final target performance and specifications by confirming the distribution of the collected data. Figure 4 summarizes the entire process for deriving target performance and specifications.

The design target vehicle is an SUV, with a target mileage of 400 km, wheelbase of 2.9 m, and weight of 3,000 kg. To derive the specifications suitable for the set vehicle, the above-mentioned process was performed, and the data distributions a shown in Figure 5 was obtained.

From the above results, it was found that the motor power required 300kW, a torque of 620Nm, and a battery capacity of 92kWh for the vehicle we intended.
4. Design Validation
To verify the results of obtained from Chapter 3, BEV was modeled and simulated.

4.1. Detail Modeling
BEV modeling was carried out to confirm the target specifications and performance of the BEV concept vehicle derived earlier. The BEV model consists of the Chassis model and the E-Powertrain architecture. The E-Powertrain architecture consists of a battery model and a motor model, and the motor model transmits driving force to the chassis model through Driveline. Chassis model consists of body model, suspension model, and wheel model. For the body, 3,000 kg of GVW was applied as a lumped mass model. For the front/rear suspension, a simple model consisting of force elements such as spring and damper and suspension mass was used, and the Pacejka model was used for the tire model.

![Figure 6. Chassis Model](image6.png)

The e-Powertrain architecture consists of a battery model and a motor model, and three architectures are configured for each drive type. The AWD type of the skateboard platform type using two motors and the FWD/RWD type composed of one motor and driveline were modeled.

![Figure 7. e-Powertrain Model(AWD)](image7.png)

4.2. BEV Simulation
A total of two verification evaluation scenarios for the development concept model were selected. Acceleration performance was confirmed by checking the time to reach the driving speed of 100 kph through the acceleration test, and the total mileage was predicted through the drive cycle driving test, and the final architecture was selected through the e-Powertrain architecture evaluation.

![Figure 9. Estimation Scenario](image9.png)

| Test            | Method                                           |
|-----------------|--------------------------------------------------|
| Longitudinal Performance | Full Acceleration Test Measurement of 100 kph arrival time |
| Range Estimation (WLTP Drive Cycle) | Check the battery SOC and calculate the estimated mileage after driving the cycle |

4.2.1. Acceleration Test
The acceleration test was conducted by setting the same motor output and torque for each drive type. As a result of the test, the AWD drive type, which showed the shortest time to reach 100 kph, showed the best acceleration performance. However, the difference in the maximum speed according to the driving method was not significant, and as the maximum speed indicates a high maximum speed of 200 kph or more, there is a need to set and limit an appropriate maximum speed.

4.2.2. Driving Test
For the development concept vehicle model, the total drivable distance was confirmed through the method of driving the WLTP Drive Cycle. The total mileage can be calculated using the formula below.

\[
E.M = \left( \frac{h}{\alpha} \right) \times 1 \text{ Cycle Distance}
\]
5. Conclusion
Various databases were created through market research related to EV development. The target performance for the development concept vehicle model was derived using the created database, and the vehicle performance was predicted through the EV System Architecture model configuration and virtual test environment. As a representative result of the driving performance results, a total mileage of 408 km could be predicted. Based on the performance prediction results, an optimal EV System Architecture model was established, and through this, the main specifications of the vehicle to be developed were derived.

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