Modeling and Verification of Conformity in Electric Vehicle (EV) for Operation Performances Using MATLAB/Simulink

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1. Introduction

Following the interest increasing of global climate change and environment, the exhaust gas control regulations have been strengthening [1-3]. So, the electric cars have been spotlighted, which are operated by motor and battery instead of internal combustion engine. In this study, there are two purposes where it is to design the simulator of the powertrain and to check out the conformity. In addition, it is to verify the simulator designed for the above goals and to compare with the vehicle's numbers. Especially, it is to investigate into function difference following the regenerative braking.

2. Method

Electric Vehicle (EV) is operated by the electricity which can be explained by the Internal Combustion Engine (ICE). That is, EV uses the electricity where the necessary power is obtained by the motor and battery. EV has the 90 % energy efficiency and otherwise the ICE has it below 40 % [4]

There is the powertrain model in Figure 1 which is one of the purpose of this work. The motor and wheels are seen.

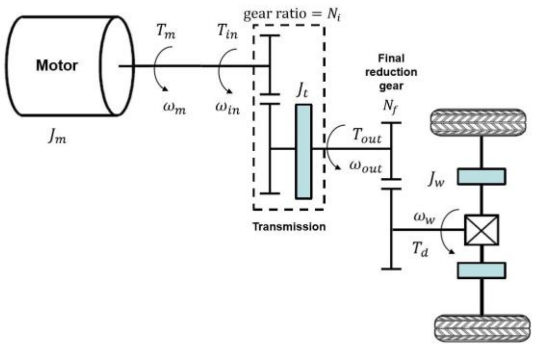

Fig.1 The EV powertrain model

For the designed motion, the equation is described as follows,

$$\dot{V} = \frac{\frac{1}{R_t}(N_f N_i T_m - F_{load} + F_{brake})}{m + \frac{1}{R_t^2}(J_m N_f^2 N_i^2 + J_t N_f^2 + 2J_w)} \quad (1)$$

In addition, the kinetic energy conversion equation for the voltage and current is as follows,

$$T_{mot} \times w_{mot} = V_{bat} \times i_{bat} \quad (2)$$

where T_{mot} is the motor torque, w_{mot} is the motor angular velocity, V_{bat} is the battery voltage, and i_{bat} is the battery current. The regeneration energy is defined it is regenerated to the electricity from the breaking energy for the wheel. So, the regenerated current is as follows,

$$i_{bat} = \frac{T_{mot} \times w_{mot}}{V_{bat}} \times \frac{1}{\eta_{bat}} \quad (3)$$

The MATLAB/Simulink supplies the simulation, auto-code generation, and continuous tasking of embedded system as the block diagram environment where the model based design tool is accomplished [5]. In this study, this is used for the simulator of EV.

3. Results

The non-regenerated breaking model is obtained as the motor/generator model and break model in Figure 2 and 3 respectively.

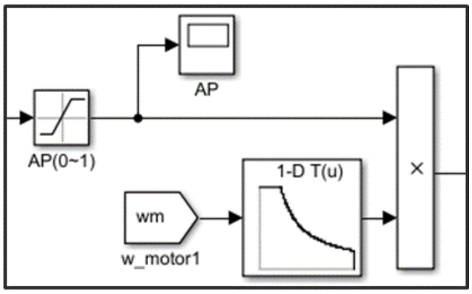

Fig.2 The motor/generator model in the non-regenerated breaking simulator

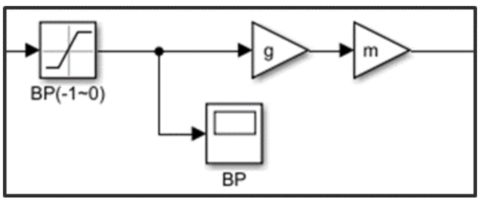

Fig.3 The break model in the non-regenerated breaking simulator

There are the results as the acceleration phase break phase (APBP) graph for deceleration range in Figure 4. Figure 5 shows the state of charge (SOC) graph for EV economy where the state of the battery charge is seen for the current charged quantity. It is found out that the SOC in Figure 5 increases following the BP in Figure 4.

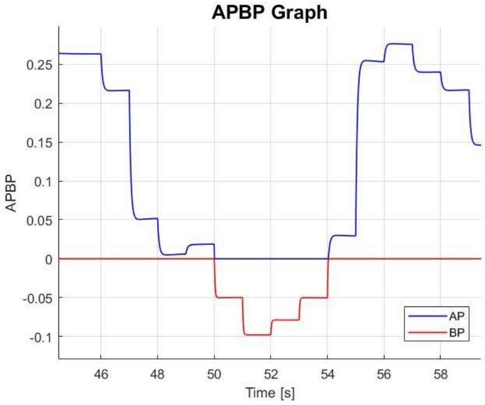

Fig.4 The APBP graph for deceleration range

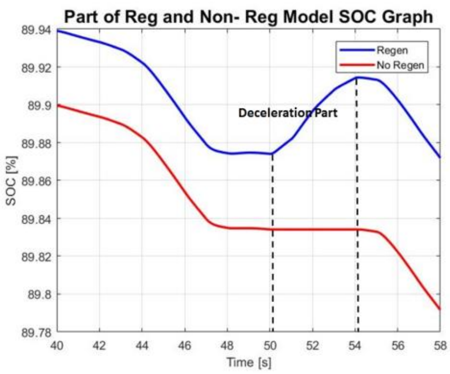

Fig.5 The SOC grape for EV economy

Figure 6 is the comparison of EV economy. So, the difference of electricity rate is 5.9 km/kWh (= 13.3 – 7.4).

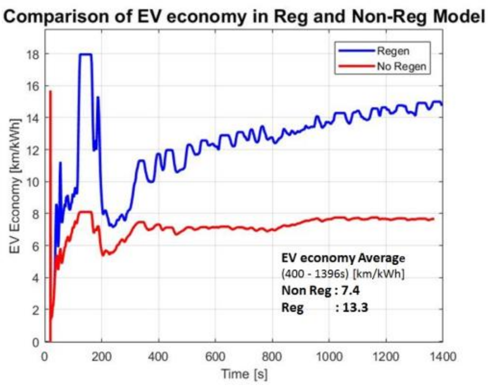

Fig.6 Comparison of EV economy
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4. Conclusions

There is the electricity capability in the downtown driving. The comparisons of model and vehicle capability is in Table 1.

Table 1 Comparisons of model and vehicle capability

	Battery SOC Shortage Rate (%)	Electrify Rate (km/kWh)	Battery Keep Time(h)	One Time Run Distance (km)
Non-regeneration Breaking Model	5.6	7.4	5.4	172
Regeneration Breaking Model	2.8	13.3	10.7	336
Real Vehicle Model	-	6.9		206

In addition, it is shown the sensitivity analysis of the electricity rate of the modeling in Table 2 where the simplified statistics as mean and modified standard deviations are used.

Table 2 Sensitivity analysis of electricity rate

	30%	Mean	70%
Non-regeneration Breaking Model	4.44	7.4	10.36
Regeneration Breaking Model	7.98	13.3	18.62
Real Vehicle Model	4.14	6.9	9.66

This shows the regeneration breaking model is better. Furthermore, the real vehicle is lower than the regeneration breaking model, because the loss value of transmission is not considered. Therefore, the regeneration model has lower value.

Acknowledgment

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