Evaluation of CO_2 Emission on Supercapacitor System as Energy Storage Device for Hybrid Electric Vehicle

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Electric double-layer capacitors have recently become of major interest as energy storage systems for hybrid electric vehicle (HEV) because of their higher power density than those of dielectric capacitors, and have a longer cycle life than batteries. In this study, the energy storage system consisted of electric double-layer capacitors for HEV was designed and evaluated its CO_2 emission on the assumption that a capacitor system was carried on HEV as an energy storage system.

The amount of input energy and CO_2 emission in the car itself and the energy storage system were calculated about the whole of the life cycle to raw material mining, raw material transportation, parts manufacturing, main body manufacturing, use, waste and recycling. The energy storage system was supposed to be constituted by the capacitor, and a lithium battery system was also evaluated for the comparison. The case that the car of 2,000 cc class was made to run in the 10·15 mode defined by Japanese Industrial Standard (JIS) was assumed. The conditions about HEV were follows; the car was 2,000 cc class (weight : 1,500 kg), and life mileage was set at 100,000 km. The hybrid system was series type one, i. e. the generator was driven by the engine, and the motor drove the wheel by the electric power. The necessary power was calculated, and the element condition shown in Table 1 was decided.

Figure1 shows the relationship between CO_2 emission in the manufacturing of the capacitor energy storage system and energy density of the capacitor cell. With the increase in the energy density of the capacitor cell, CO_2 emission in the system manufacturing lowered. The CO_2 emission was reduced by 93 % in comparison with 1 Wh/kg for 15 Wh/kg of energy density, which was the advanced target of the Department of Energy (DOE),[1] was achieved. In the following, capacitor energy density and the maximum permissible depth of discharge (DOD) were set to be 15 Wh/kg and 94 %, respectively. Figure 2 shows the effect of a regenerative control on stored energy for JIS 10·15 mode. In case of regenerative ratio of 50 %, 69.3 % of DOD was necessary for 1 cycle, and surplus energy was 222.6 Wh for the maximum permissible depth of discharge. Figure 3 shows the effect of energy storage system capacity on CO_2 emission for life mileage of HEV with capacitor system. The surplus energy per 1 cycle was supposed to be utilized for the next cycle in case of DOD less than 94 % in the 1 cycle of 10·15 mode. From the result, CO_2 emission in the whole life cycle for HEV decreased 35.7 % with increasing system capacity from 666 Wh to 903 Wh though CO_2 emission increased with system capacity for energy storage system manufacturing. The priority of capacity enhancement was clarified with evaluation in not only the system manufacture but also the whole of the life cycle.

1) T. C. Murphy, R. B. Wright and R. A. Sutula, *ECS-PV 96-25*, p. 258, (1997).

Table 1 Specification of power transmission devices.

Output of engine	60 kW
Thermal efficiency of engine	35 %
Output of motor	100 kW
Generator efficiency	90 %
Inverter efficiency	95 %
Efficiency of charge/discharge	93 % for Capacitor 85 % for Li battery

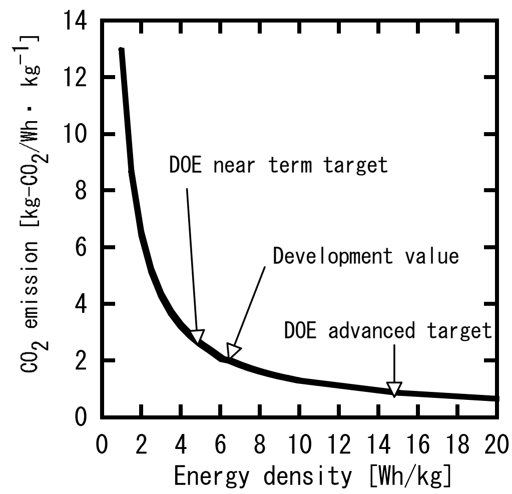

Fig. 1 CO_2 emission on energy density of capacitor cell for manufacturing as energy storage system.

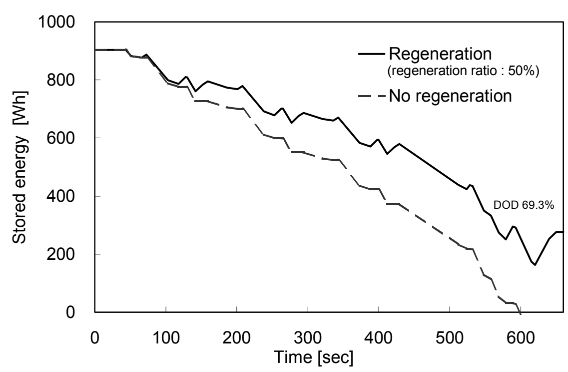

Fig. 2 Effect of a regenerative control on stored energy for JIS 10·15 mode.

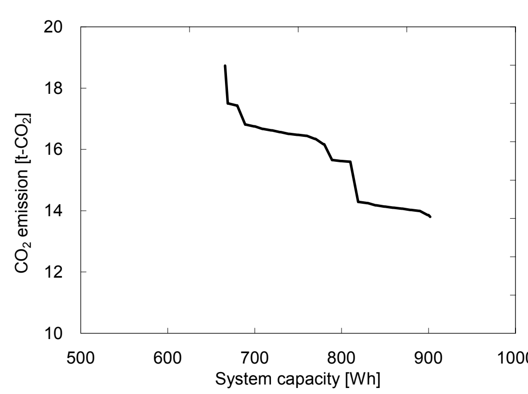

Fig. 3 Effect of system capacity on CO_2 emission for life mileage of HEV with capacitor system.