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Energy Analysis by Traveling Mode Pattern of Electric Motor/Generator

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In recent years, global efforts toward electric vehicles have been remarkable. Our laboratory is engaged in research on regenerative energy from the regenerative function of electric vehicles. In this report, the driving and regeneration quantities were obtained from the acceleration/deceleration pattern in the practical running mode, and the mode pattern was evaluated from the viewpoint of the energy analysis. In addition, the capacitance of the capacitor for storing the regenerative energy was measured, and the degradation was confirmed.

The motor is accelerated to 2000 [rpm] at 20 [sec], maintained at 2000 [rpm] for 20 [sec], and decelerated to 0 [rpm] at 20 [sec]. This is called the “Basic pattern”. This pattern, the "Constant deceleration pattern" with deceleration time from 2000 [rpm] to 0 [rpm] set to 30 [sec], 35 [sec], and 45 [sec] longer than the "Basic pattern", and the "Nonlinear deceleration pattern" with deceleration time from 2000 [rpm] to 0 [rpm] set to be nonlinear, in which deceleration is started slowly and quickly from the middle, were operated 4 ~ 6 times each, and the current and voltage values were measured. The regenerative electric power was obtained from these values. Figure 1 shows the amount of energy recovered and the amount of energy remaining at the time of stopping of the three types of patterns. The comparison between the “Basic pattern ” and the “Constant deceleration pattern” shows that although there is not much difference in the amount of recovered energy, the longer the deceleration time, the less energy is consumed for deceleration. In this case, it was considered that natural deceleration energy such as mechanical loss could be utilized more in the control which keeps deceleration for a longer time, and as a result, added electrical consumption energy would not be generated. In the comparison between the “Basic pattern ” and the “Nonlinear deceleration pattern”, the amount of recovered energy is large, and the amount of residual energy is small. The “Nonlinear deceleration pattern” is considered to be because the amount of deceleration from the point of switching to energy consumption to 0 [rpm] is larger than the “Basic pattern”.

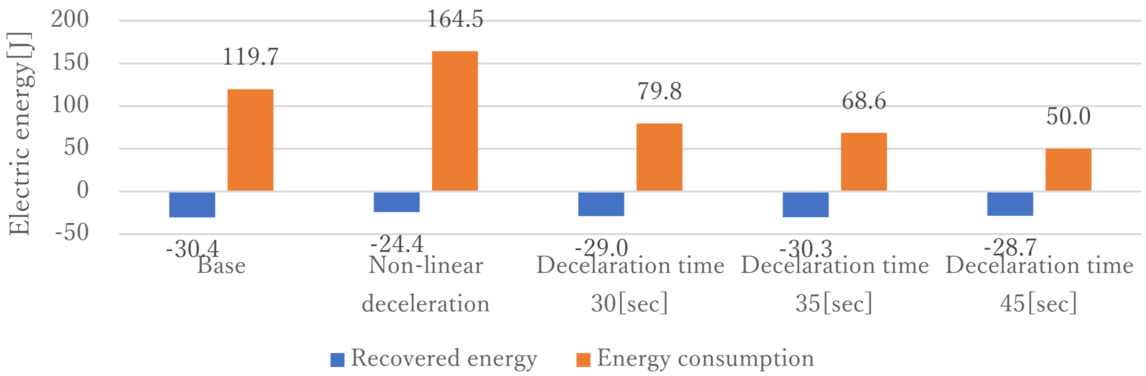

Fig.1 Amount of recovered energy in motor control

Next, the results of the capacitance measurement experiment will be described. For measuring the capacitance of the capacitor, the capacitor is previously boosted to 24 [V] and discharged using a resistor of R = 10 [Ω]. At that time, the voltage value was measured, and the charge in the discharge was obtained by the relation of equation (1).

$$Q = VC \tag{1}$$

Since the electric charge obtained by the equation (1) is related to the equation (2), the electrostatic capacitance C is obtained by modifying the equation (2).

$$q = Ke^{-\frac{1}{RC}t} \tag{2}$$

The discharge curve measured in the experiment was faster than the theoretical value up to about 800 [sec] than that obtained by substituting the manufacturer's nominal capacitance value into equation (2). The present capacitance value calculated using the method described above was 41.5 [F]. However, since the starting point of the equation calculated by the approximated curve did not match the discharge curve of the experiment, and this is the wrong relation in using the theoretical equation, the capacitance value was calculated taking the degradation into consideration. The change ΔC of the capacitance of the capacitor disclosed by the manufacturer of the capacitor was taken into account for the capacitance C of the equation (2), and the discharge curve obtained in the experiment was considered to be the empirical equation.