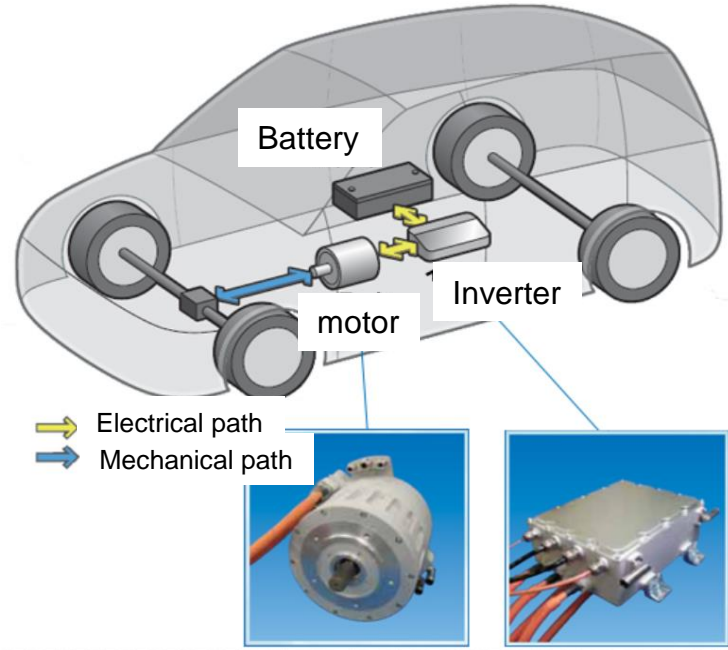


Deterioration factor of electric system components

1. Electric system components

2. Efficiency losses of electric components



Japan will explain this document with the understanding that "Only" these will affect the degradation of electricity consumption. If there are other factors that could affect degradation, please indicate them specifically.

Motor efficiency: motor output / motor input power (voltage and current)

< Factors affecting efficiency losses >

- 1) Current decrease due to increase in internal resistance of the coil copper wire (See P.3,4)
- 2) Current decrease due to partial discharge between coil wires (See P.3,4)
- 3) Output torque decrease due to magnetic flux density drop of permanent magnet (See P.3,4)
- 4) Reduction of transmission efficiency due to friction between Motor shaft and axles (see P.5)

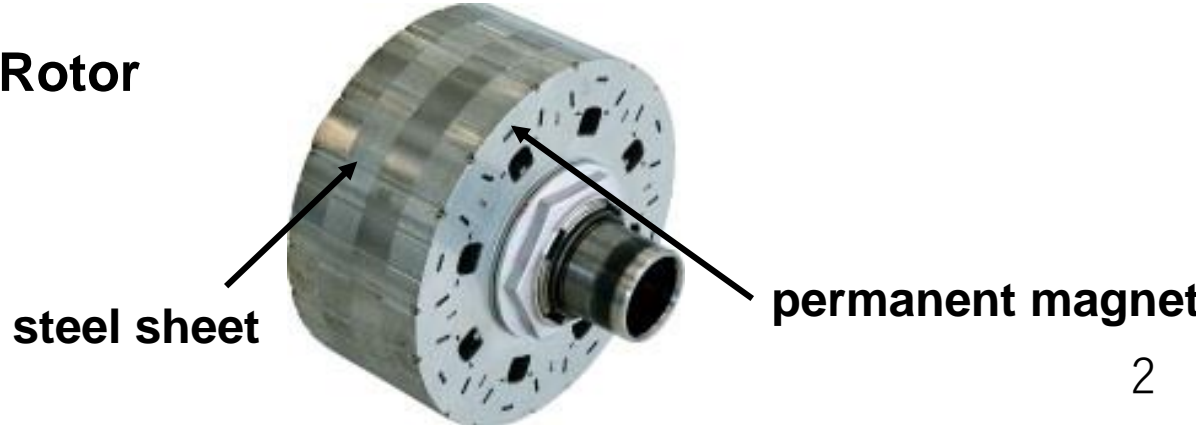
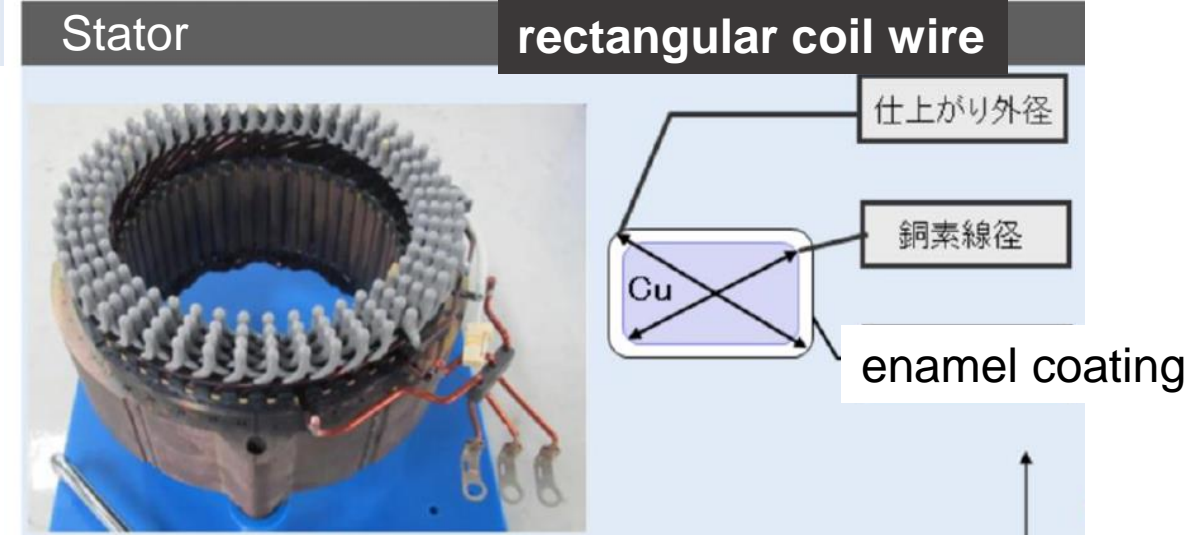
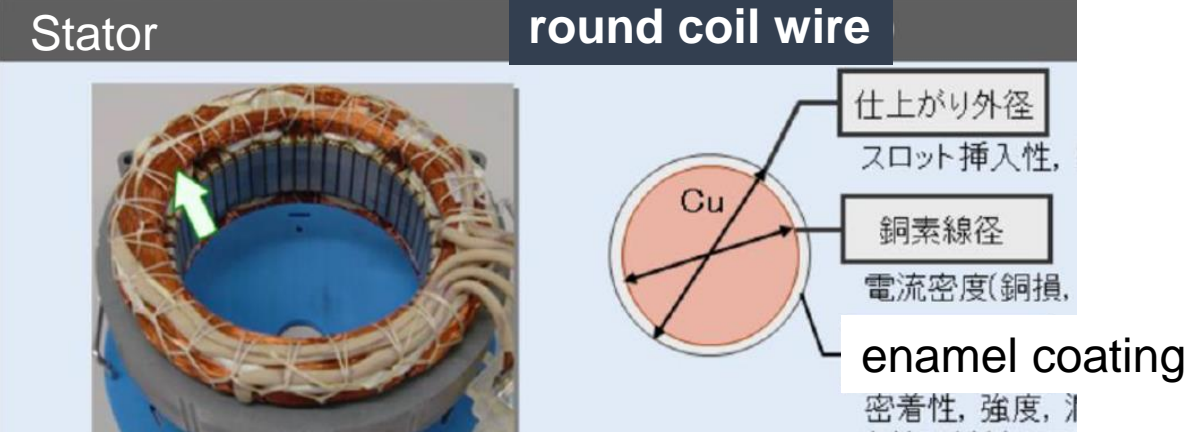
Inverter efficiency: inverter output/inverter input power (voltage and current)

< Factors affecting efficiency losses >

- 1) Switching loss of IGBT (See P.8)

3. Efficiency loss factors for synchronous PM motor components

- 1. Current reduction due to partial discharge between wires due to deterioration of enamel coating.
 - 2. Reduction of magnetic force of permanent magnet due to high temperature operation.
- Note;**
 Since the maximum current value of the copper wire is known, the wire diameter and resistance value are designed so that the internal resistance does not deteriorate or is not affected by those factors.



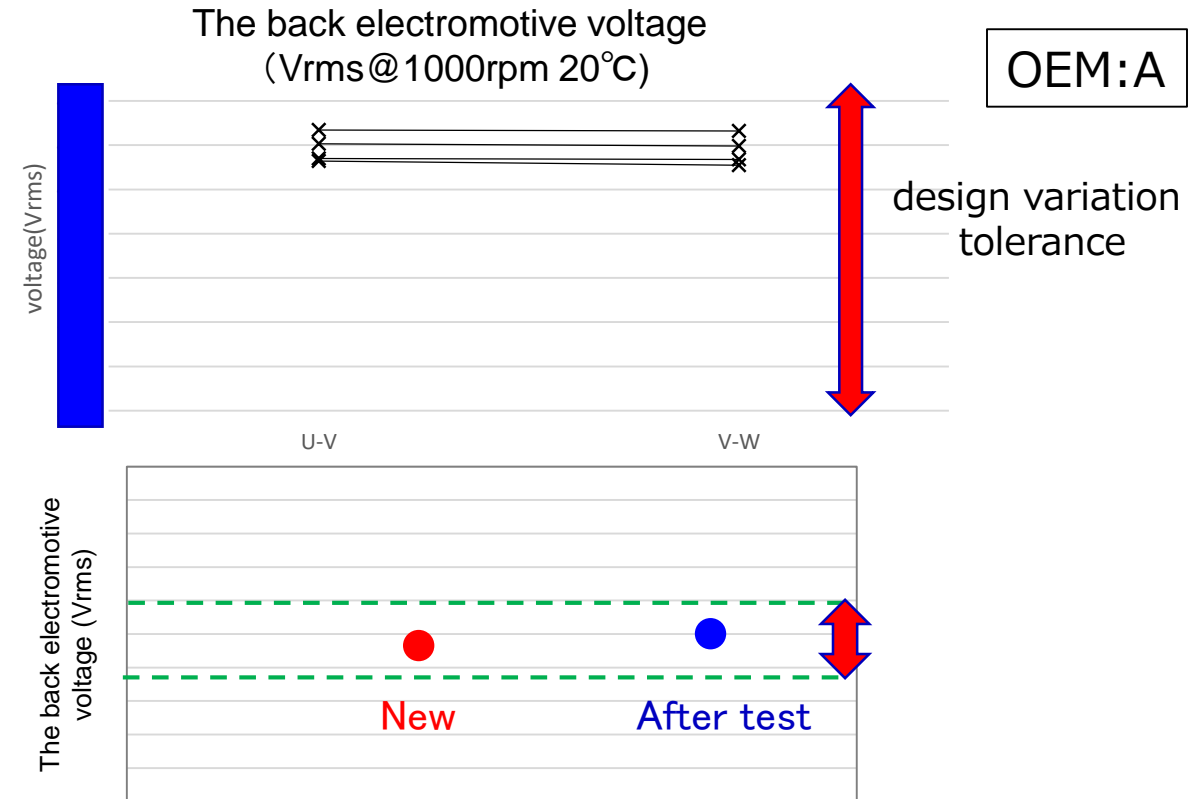
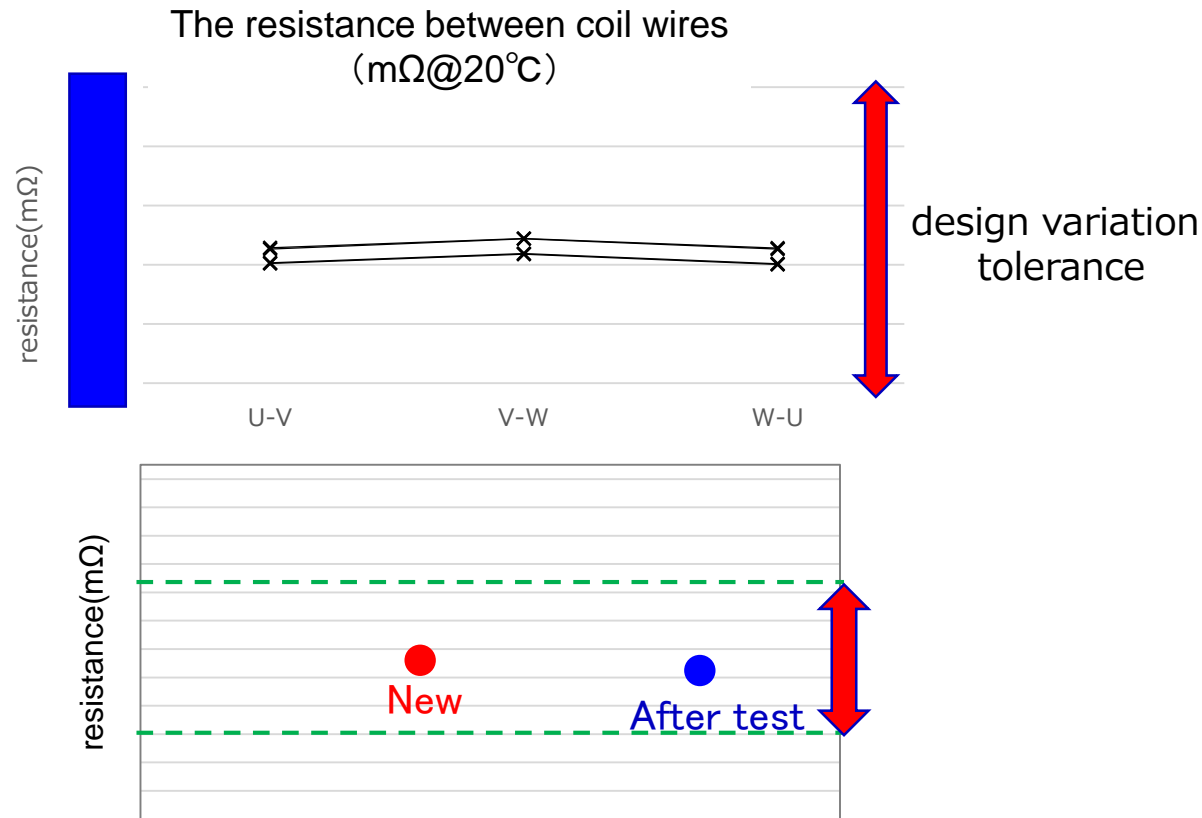
4.1 Results of Motor Durability bench tests

Same evaluation criteria applied for new car motors and aged motors collected from the market.

The results of the durability tests are within the design tolerance range for new vehicles

1. As the resistance in the coil and between coil wires is within the design tolerance, it is judged that there is no influence to the electric consumption.

2. The back electromotive voltage is also within the design tolerance, and demagnetization does not occur



In the motor in which the insulation of the enamel coating deteriorates, the balance of resistance between wires and the resistance decrease compared with the normal value. A normal value cannot be obtained.

The motor is not used in the temperature range where irreversible changes of the magnetic steel plate, coil and magnet occur.

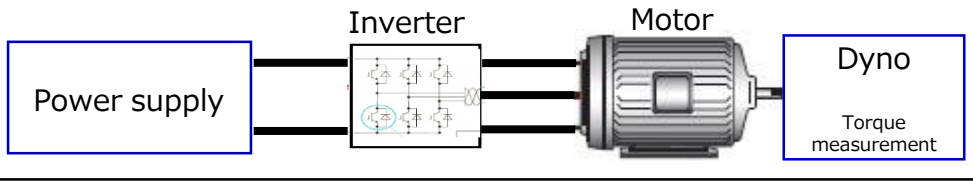
In addition, cooling design and control limit the operating area.

4.2 Results of Motor Durability bench tests

OEM:B

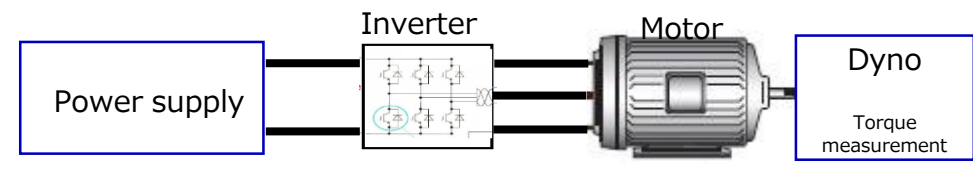
Measurement of aged PEV motor output

Step1 Torque measurement of **new motor**



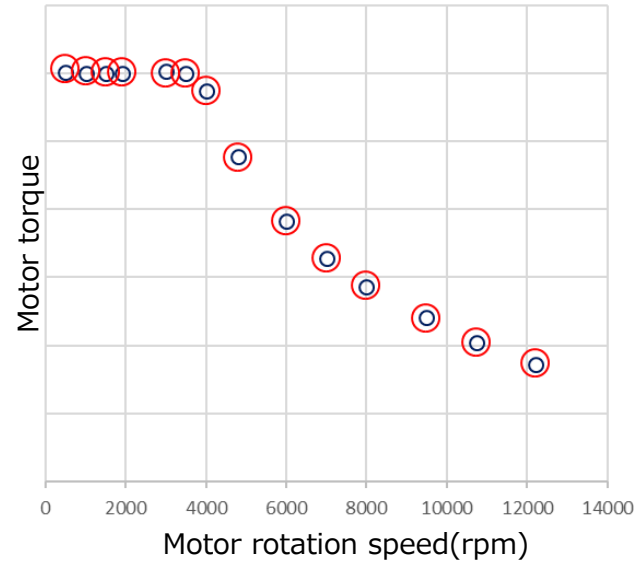
Step2 Replace aging degradation with bench test.

Step3 Torque measurement of **aged motor** .



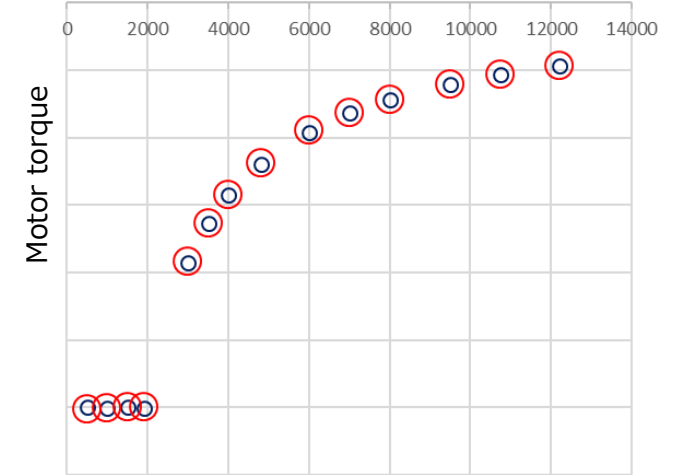
Result: Drive Torque

○ New Motor ○ Aged Motor

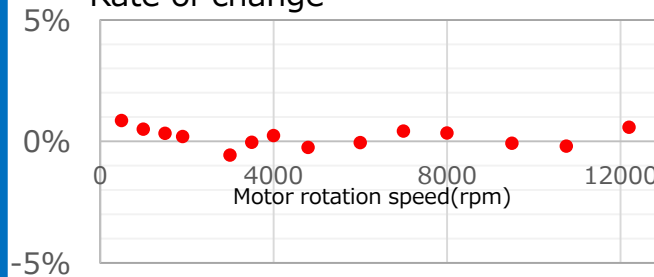


Result: Regenerative Torque

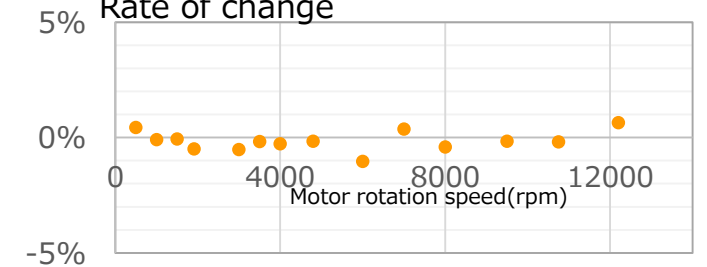
○ New Motor ○ Aged Moto



Drive Torque
Rate of change

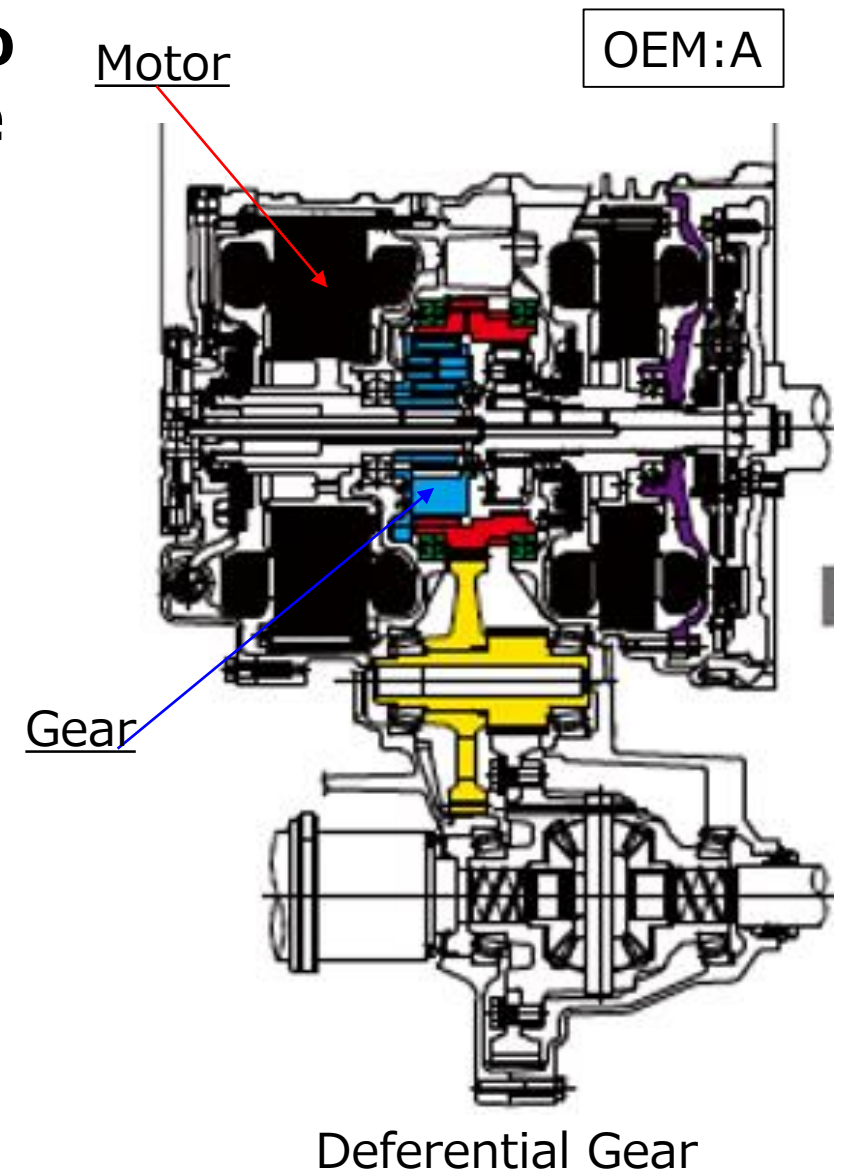
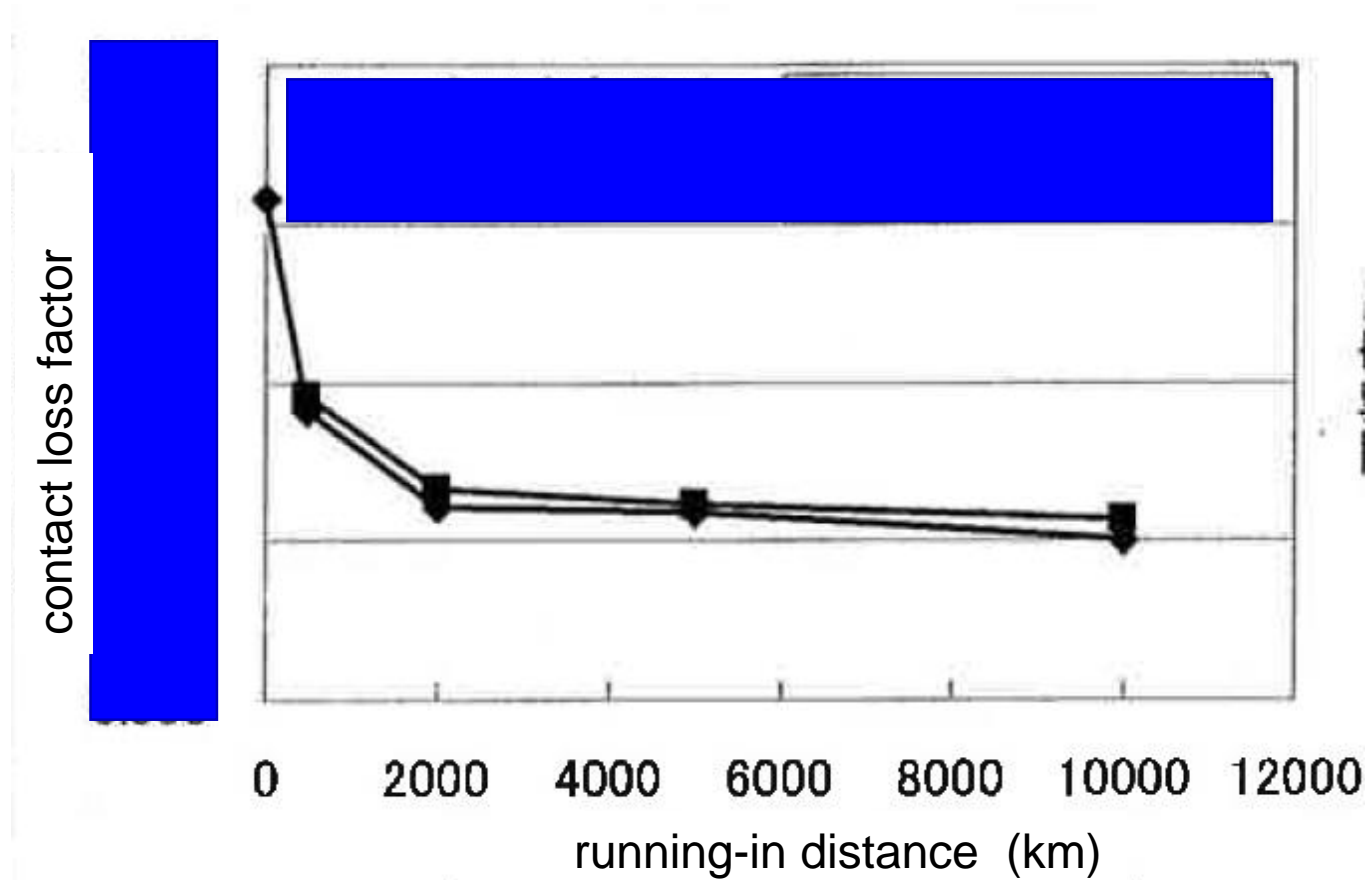


Regenerative Torque
Rate of change



The effect of Motor degradation is negligibly small.

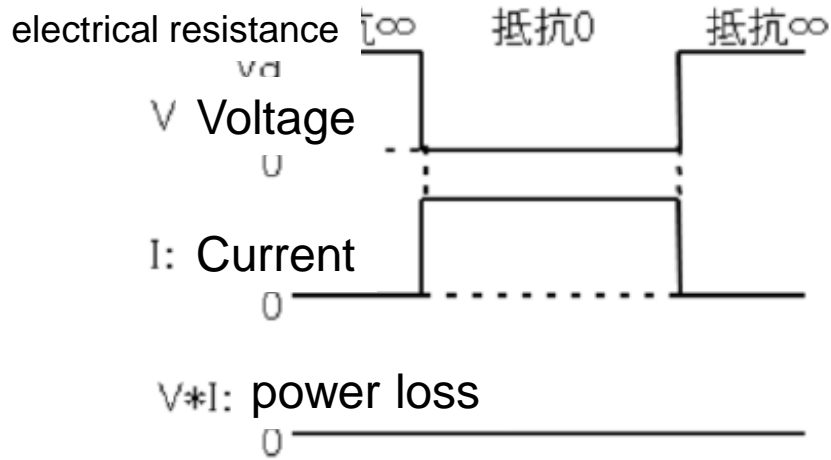
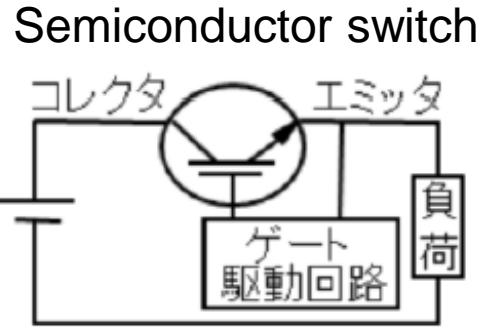
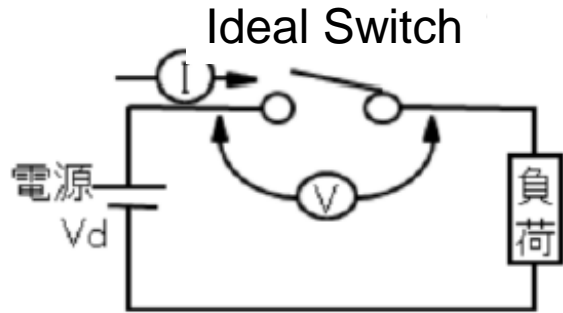
5.Reduction of transmission efficiency due to friction loss between motor shaft and axle



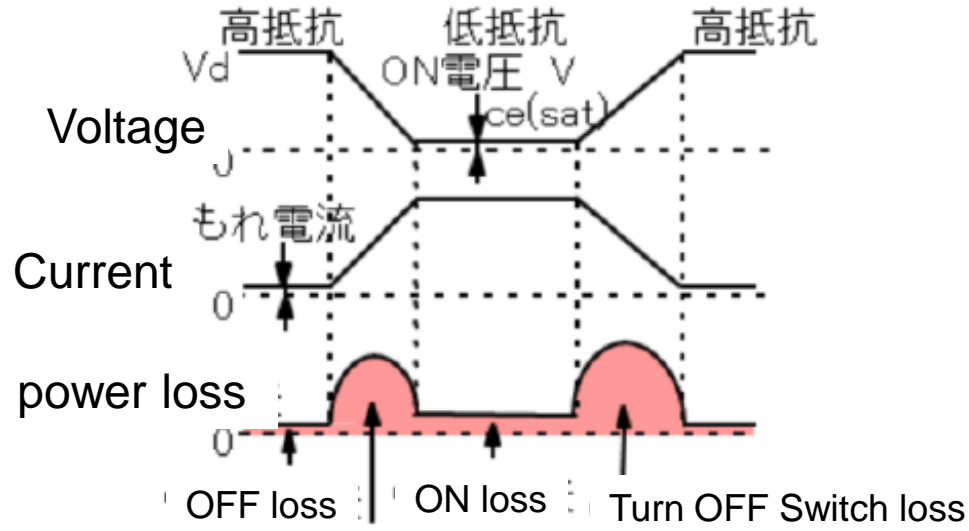
The contact loss of the gear, which has the largest effect, is large in the initial stage, but decreases when the gear is run-in, and it does not adversely affect the electric consumption.

6. Inverter loss

Semiconductor switch : Losses occur unlike with an Ideal Switch



power loss: 0



③ Turn ON Switch loss

①②: 主に電流に依存
 ③④: 電圧・電流・キャリア周波数に依存

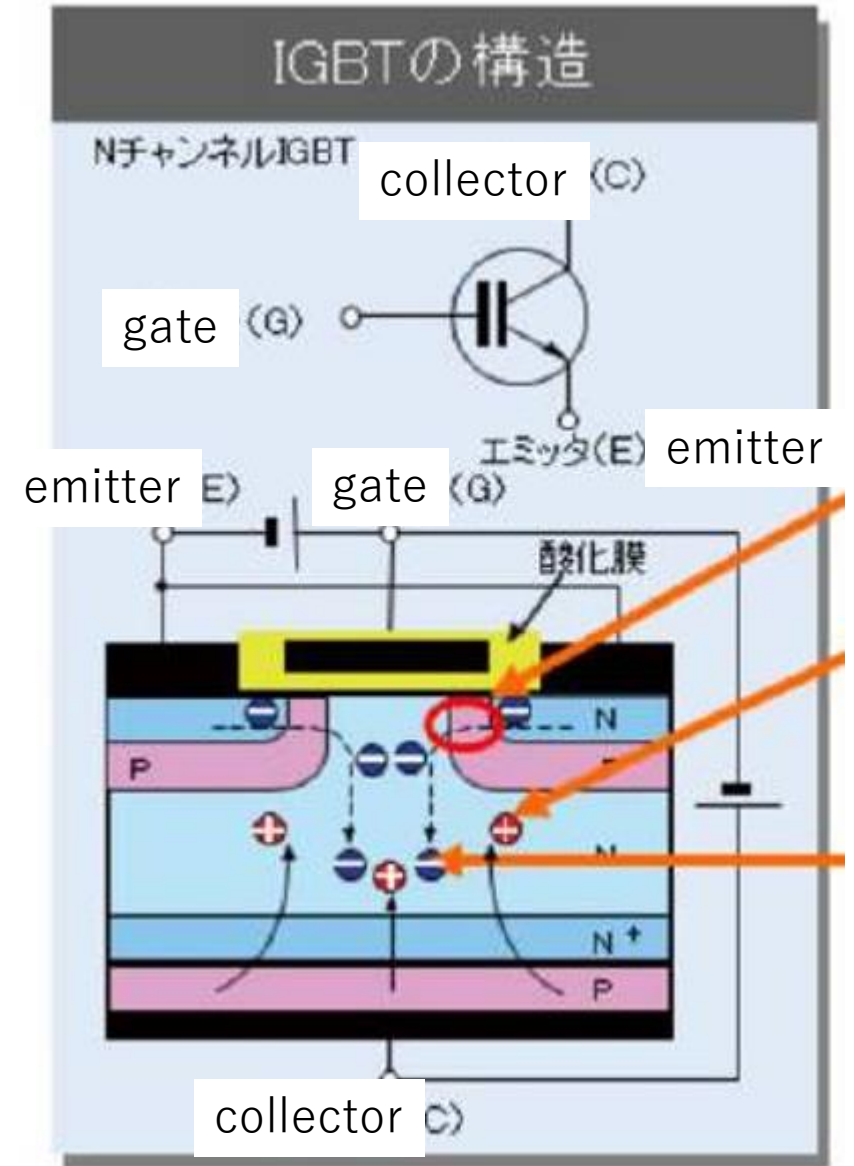
steady loss
switching loss

7. Deterioration of Inverter losses

Inverter loss due to switching occurs as described in the previous page.

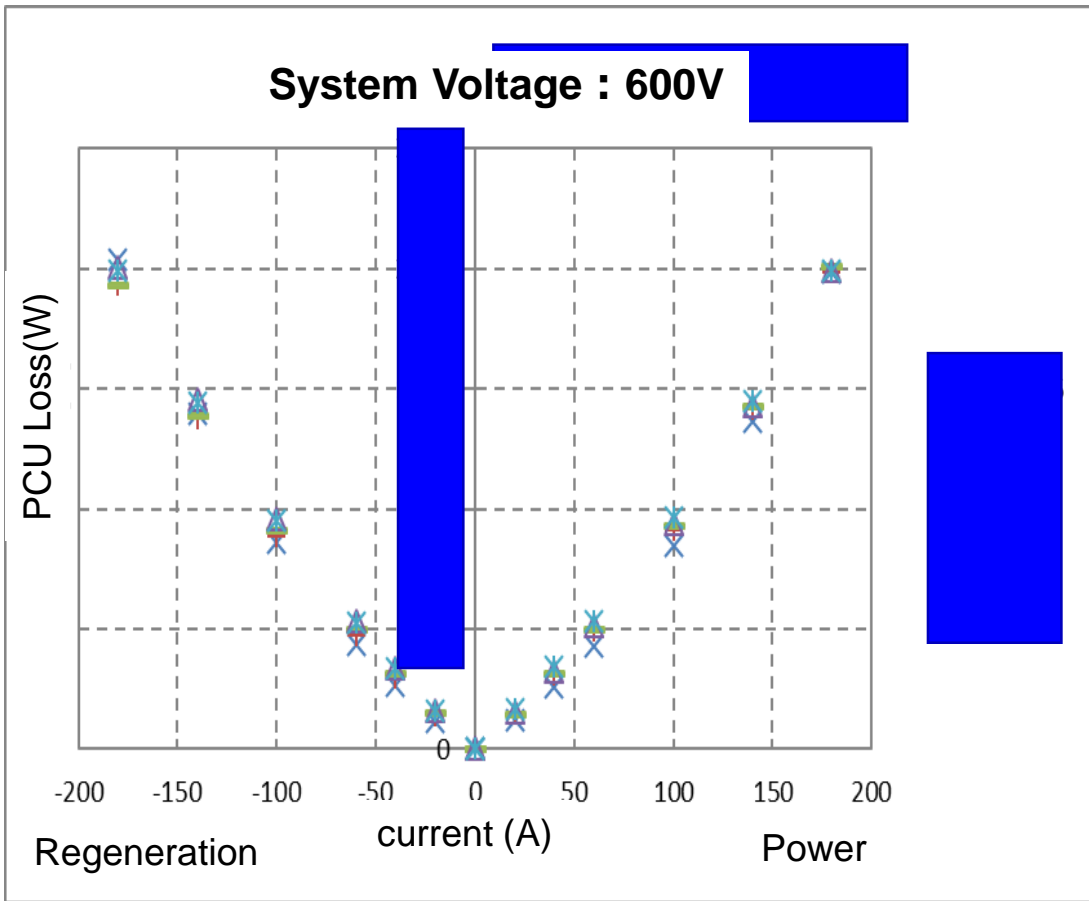
The switching mechanism of the IGBT does not involve contact, but uses the movement of electrons as shown in the right figure, and in principle, there is no wear type loss degradation.

Degradation inside the device occurs, but the degree of influence is small and does not appear in the performance of the vehicle.

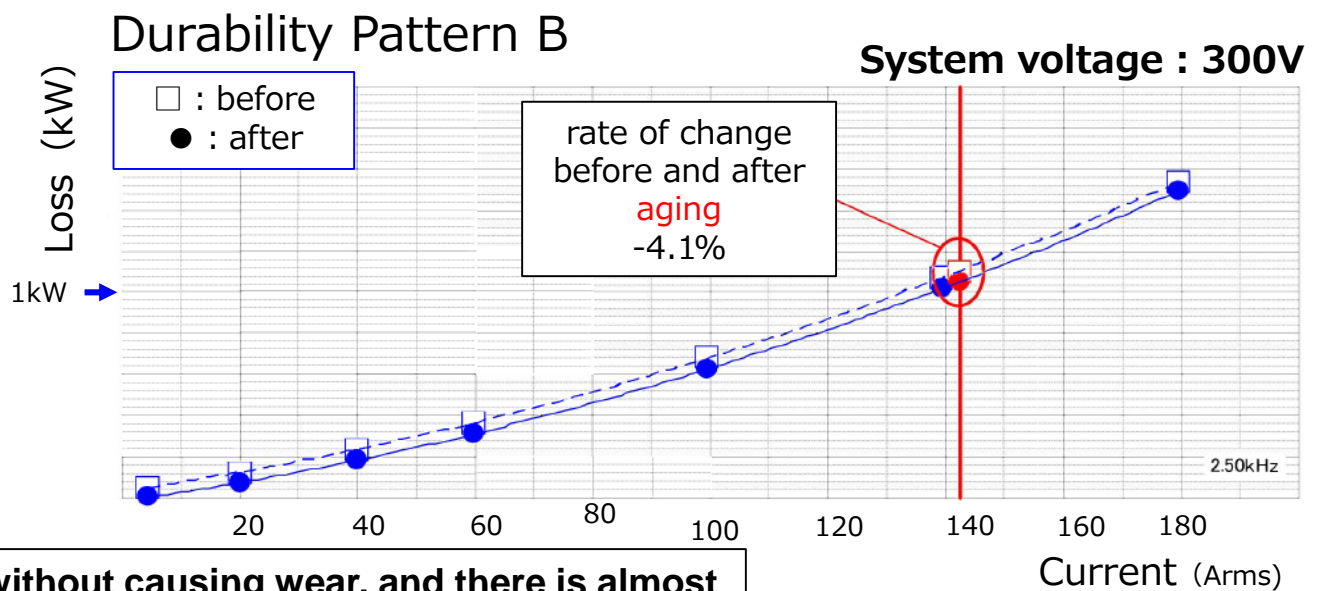
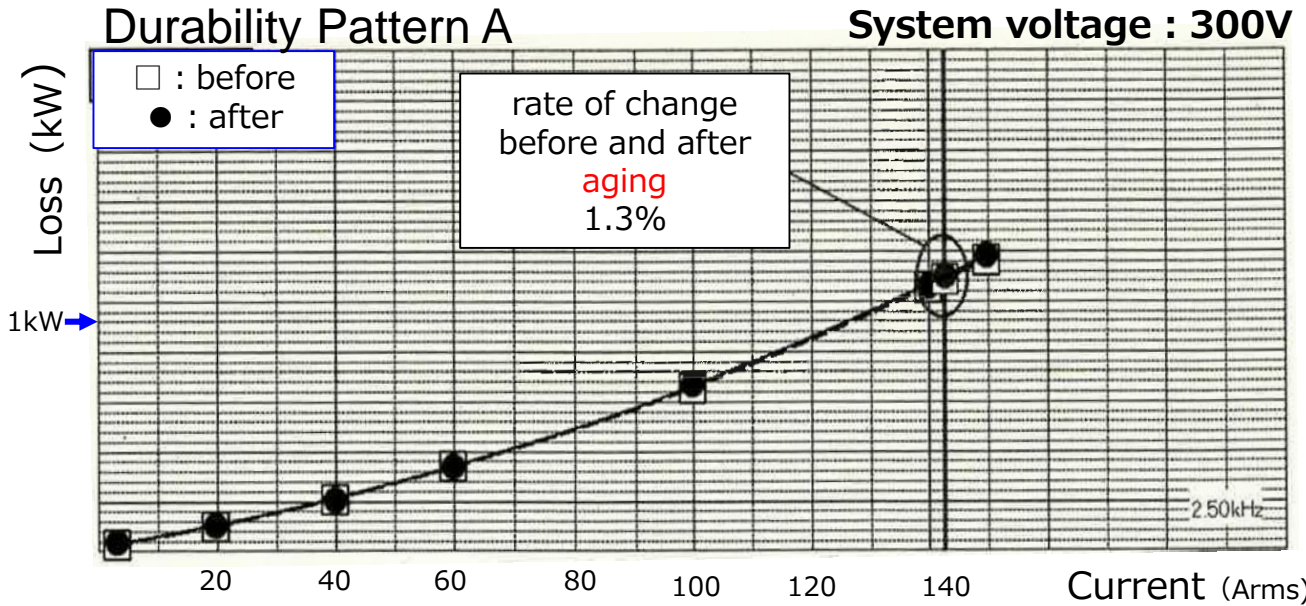


8. Results of Inverter Durability bench tests

about 2 kW (3.8%) Inverter loss
for a motor performance of 53 kW



Loss Measurement Results (@ bench)



The loss of 2kw is an energy loss due to the transfer of electrons without causing wear, and there is almost no deterioration, and even after durability test, it is within the design tolerance for new cars

9. Summary

From the shown results,
it is considered that the degradation of the electric consumption due to the degradation of the electric components is negligibly small.

2. Therefore, the SOH_Range only needs to monitor the degradation of the battery.