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Experimental Study on the Electrical Performance of an Automotive Actuator DC Motor According to Brush Surface States

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Abstract
This study was aimed to figure out the effect on electrical characteristics of DC motor according to the brush surface states related to surface roughness and the other purpose was the effect of brush surface corrosion, which was formed by the accelerated testing based on Arrhenius-Peck model, on electrical contact. In order to investigate the relationship with the electrical contact according to the brush type, the brush-commutator of the DC motor applied to the actuator of passenger vehicles and the brush-commutator applied to the commercial vehicles actuator were evaluated together, and named with type A and type B, each. The higher surface roughness was, the better the circuit was energized, and type A brushes were more sensitive to the surface roughness. In terms with corrosion, contact resistance tended to be proportional to the test cycle for both types of brushes, and measured values of the contact resistance for type B brushes were higher than type A.

Keywords Automotive actuator · Accelerated life test · DC motor brush · Electrical contact · Surface corrosion · Surface roughness

List of symbols

a	Brush insertion distance, mm
ω	Rotating angle of a bolt, degree
d	Effective diameter, mm
l	Lead dimension of a bolt, mm
R_o	Contact resistance of the DC mortor, Ω
I	Current measured through shunt resistance, A
V_{in}	Applied voltage by the power supply, V
$V_{measured}$	Measured voltage between c and d of Figure 4, V
V_d	Voltage drop, V
AF	Acceleration factor
RH_n	General humidity condition, %RH
RH_a	Accelerated humidity condition, %RH
E_a	Average conservative activation energy, eV
k	Boltsmann's constant, eV/K
T_n	General temperature condition, °C
T_a	Accelerated temperature condition, °C
t_{test}	Test duration of HAST, hour
CL	Confidence level, %
R_T	Test reliability, %
N	Sample size
β	Shape parameter of the Weibull distribution
t_{use}	Total time exposed to the user environment, hour
R_a	Roughness expressed with an arithmetic mean height, μm
l_e	Evaluation length, mm
x	Horizontal component of a surface to be measured, mm
$z(x)$	Height of the assessed scale-limited profile, μm
j	Current density, A/mm^2
N_{br}	Number of brushes
S	Area of brush surface (width × height), mm^2
A and k	Model parameters obtained through the nonlinear regression

1 Introduction

The DC motor is constituted with a relatively simple circuit in terms of an operation and economically advantageous compared to the BLDC motor, so it is widely applied to automotive electronics, especially actuators. PWM control is mainly applied to the DC motor in order to precisely control

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