SUMMARY OF Ph.D. DISSERTATION

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Title

Methods for Improving Lifetime of Automotive Motor Brushes

Abstract

DC motors are indispensable to improve automotive functions. Currently, approximately 150 motors are installed on a luxury car and this number is increasing year by year. This paper reports the technology and methods for improving the brush's lifetime which is essential to increasing the competitiveness of motor products from the viewpoints of reliability and durability because the brush's lifetime decides the motor's lifetime.

Chapter 1 provides the background and the objective of this study and summarizes previous studies.

Chapter 2 provides the fundamentals of theory, practice and knowledge of brushes.

Chapter 3 describes a process used to establish a lead-free technology in brush materials for starter motors. Lead inhibits the brush-electric-resistance from increasing in high-temperature or high-humidity atmospheres, and reduces brush wear. By addition of zinc and silver as alternatives to lead, a lead-free brush material that had equivalent or better lifetime and performance than that of a lead-added brush was developed. Furthermore, in a brush for a high-load starter that is used in high-temperatures, the brush's lifetime could be improved by adding zinc phosphate because zinc phosphate has an effect of improvement of the lubricity at high-temperature. The lifetime of the developed zinc phosphate-added brush was about 1.5 times longer than that of a lead-added brush.

Chapter 4 describes a spark (arc) reducing effect of capacitors in a commutation circuit of a liquid pump motor and the characteristics of the effect. The commutation circuit with capacitors generated the same arc energy as a commutation circuit without capacitors above a certain residual current (the limit-residual-current). However, an excellent spark reducing effect that reduces brush wear was observed below the limit-residual-current. The limit-residual-current increased as the capacitance increased. Furthermore, increasing the revolving speed of the commutator increased the limit-residual-current when the commutator material was carbon. However, this phenomenon was not obtained when the material was copper.

Chapter 5 describes a brush-contact-condition for reducing commutation spark in order to reduce brush wear. A larger spark occurred when an offset-load existed on the rear end of the brush because the contact resistance between the brush and the commutator became extremely low at the brush-rear-end by the offset-load. Therefore, the electrical current flowing between the brush and the departing commutator segment became higher. At this time, the insufficient commutation was accelerated and caused a large spark. On the other hand, adding an offset-load on the front end of the brush was an effective measure to reduce sparking. A spark reducing effect was observed in a brush that had an inclination angle at the spring contact part of the brush in order to add the offset-load on the brush-front-end.

Chapter 6 summarizes the results of this study.