Effect of Various Phenomenon on Induction Motor

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Abstract

The motor of a mini electric vehicle uses dozens of storage batteries as power supply, which has low voltage and large current. Therefore, the loss and temperature raise of the motor is high. In this paper, the loss of different induction motors for mini electric vehicles is calculated and the effects of rotor materials and air gap length on the performance of these motors are studied. The analyses show that the efficiency of the motor with a copper mouse cage rotor is considerably higher than that of the motor with a aluminum rotor. The temperature raise of both an air cooling and a water-cooling induction motor is analyzed, which demonstrates that the temperature raise of the motor windings is higher than that of the other parts, and the temperature raise of the water-cooling motor is lower than that of the air-cooling motor. To verify the results of the theoretical analyses, four prototype induction motors (aluminum rotor, copper mouse cage rotor, air-cooling and spiral groove machine) have been designed and processed. The experiments to measure the efficiency and temperature raise were carried out on these motors. The experimental results prove that the theoretical analyses are correct.

Keywords*:*
mini electrical vehicle; induction motor; aluminum rotor; copper rotor; temperature raise

I.Introduction

Energy deficiency and environmental contamination are two major challenges which were met in the development of automobile industry in contemporary society[1]. Electric vehicle which was used as a kind of energy-efficient, non-pollution, ideal “zero discharge” vehicle has been paid more attention to in recent years. With the rapid development of high-technology of power electric and control, the mini electrical vehicle has a rapid development in recent years. However owing to the high price of mini electrical vehicle, popularizing the mini electrical vehicle is still a certain difficulty. Mini electrical vehicle which has advantages of small volume, energy conversation, convenience and low prices and so on has been a hot research spot in today’s electric vehicle fields. The motor drive and control system is the core of electric vehicle. Induction motor which has advantages of simple structures, low prices, easy maintenances, broader constant power operation scope and so on has a broadest application in electric vehicle fields. It is demanding that the motor drive system applied in Electric Vehicle not only has a high starting torque and wide constant-power range of variable speed, but also has a high efficiency in all velocity range[2]. The mini electrical vehicle uses the storage battery with induction motor as power supply. The low supply voltage leads to a large motor current, and a large current leads to the high Temperature raise and loss of motor. The loss increases and the efficiency decreases. The temperature raise has an effect on the performances, insulations and service life of motor, so how to reduce loss and temperature raise of motors, and to increase the efficiency of motors and reliability of operation has become the key of the motor design for of mini electrical vehicle. This paper discusses how to reduce loss and temperature raise and to increase the efficiency of motors, aiming at the features of low supply voltage and large current of motors for mini electrical vehicle

II. The Analysis of Magnetic Performance of Induction Motor for the Mini Electric Vehicle

Loss Analysis

The loss of motor mainly includes the copper loss of stator winding, copper (or aluminum) loss of rotor winding, iron-core loss, mechanical loss and additional loss[3]. Equation (1) is shown as follows:

Psum =P(cu1) + P(r2)+P(fe)+P(fw)+P

Psum is total loss; Pcu1 is copper loss of stator winding; Pr2 is rotor loss (aluminum loss or copper loss), P(fe) is iron-core loss; P(fw) is mechanical loss; P is stray loss.

When the power and the voltage are given, the copper loss of stator winding can be decreased by increasing wire diameter. However, increase of wire diameter restricted by the slot filling factor. So it ishard to calculate mechanical loss Pfw correctly. Generally we refer to existing motor parameters and calculate on the basis of empirical formula. Because of mechanical loss which has little influence on efficiency generally is relatively small, we do not take it into consideration for the time being. Iron loss includes eddy current loss and hysteresis loss. Stator and rotor core which adopts lamination structure can decrease eddy current loss vastly. Rotor loss and the square of current are proportional with resistance. Rotor current is generated by stator rotating magnetic field. And rotor current is not easy to change restricted by the voltage of motor. If the rotor resistance droops, the rotor loss will decrease. Decreasing rotor resistance is an effective measure to reduce motor loss.

Effects on the Performance of Motor by Rotor Materials

Rotor materials determine rotor resistances. Choosing lower resistivity can reduce rotor resistances effectively. Because the resistance rate of copper is half of aluminum's. Adopting induction motor of copper rotor can vastly reduce rotor loss, thus efficiency of motor is increased. To research how much copper rotor and aluminum rotor affect the performance of motor, this paper is emulated and calculated to aluminum and copper rotor using rated voltage 34 voltages (the voltage inverted by direct current 48 voltages), frequency 50Hz, rated power 4kw, stator 30 slots, rotor 26 slots and rotor skewed slot motor by magnetic circuit calculation and Flux simulation. The induction motor (prototype obtained by transforming Y2 motor) of aluminum rotor and copper rotor are manufactured. To probe the veracity of calculation further, we build finite element of motor by Flux software.

Influences on the Performance of Motor by the air gap length

The air gap length of induction motor is an important parameter in motor design. The air gap length not only influences the loss of motor, but also the power factor of motor. The air gap length is too big which will make the exciting current increase and the power factor decrease. The air gap length is too small which will make mechanical production difficult. In order to analysis the influence by air gap length on the performances of motor, this paper will contrast the current and power parameters of induction motor of copper rotor at different air gap length by magnetic circuit calculation and Flux simulation.

Induction motor applied to the mini vehicle has the characteristics of low voltage and large current. Onone hand the loss of motor increases, on the other hand large current causes the temperature raise in themotor. While the temperature raise affects the performance of the motor, insulation properties, and servicelife, so how to decrease the temperature raise to guarantee the reasonable temperature scope and how todevelop the reliability of the motor operation become another key point in the motor design.The heat exchange in motor mainly includes the heat conduction and convective heat.

In equation (4) □ is the thermal conductivity of objects, and *T* is the temperature of the objects (□), andqv is the unit volume of heat-producing rate. From (4), we know that the heat transferred by conduction isproportional to thermal conductivity. To ensure the safety of the motor running, the large motor often usesthe iron core of the stator and of the rotor to the air-cooling or hydrogen-cooling structure of the airventilation [6-8]. Small motor has less calorific value and setting the air ventilation of the stator and rotorincreases the complexity and difficulty of machining process. Thus, cooling structure by surface of the motor is generally used. The thermal conductivity of water is larger than that of the air, so the watercoolingstructure is far more advantageous to reducing temperature of the motor.Via establishing the heat circuit model of air-cooling motor with fins and of the water-cooling motorwith spiral groove, we analyze the temperature raise in all parts of the motor. In Figure 6, P1, P2 and PFe are stator copper loss, rotor copper loss and iron loss respectively. R11, R12, R4are thermal resistances between stator iron and stator winding, stator iron and rotor, stator iron and housing.R2, R3, R5 are thermal resistances at the end of the rotor, at the end of the stator, at the end of statorwinding. R6 is thermal resistance of the surface of the foot. Due to the heat productivity of the motor winding being the most serious, we mainly analyze the slot windings

III. Experimental analysis

Experiment of the Motor Efficiency

To verify the accuracy of the calculation further, we test the motor of the rotor of processed aluminum and copper. The test consist of the induction motor of aluminum rotor, the induction motor of copper rotor, YASKAWA Inverter Varispeed G7, Dynamometer MagtrolHD-825, Power Analyzer WT3000 and so on. The test platform is shown in Figure 1.

Fig.1 Test of motor efficiency

Temperature Experiment of the Motor

The temperature experiment of the motor consists of air-cooling and water-cooling induction motor of copper rotor, drag motor, Torque Sensor JN338-50Nm, YASKAWA Inverter Varispeed G7, Telemecanique Inverter Altivar 58 and Power Analyzer WT3000.. The temperature is measured by heat resistance WT100 buried in the slot of the motor, the end windings and the yoke of iron core of the stator. When we measure that motor speed is 2880rmp and the torque of motor is 10Nm, the temperature curves of slot windings, end windings and the yoke of iron core of the stator, in which WaterEW, WaterSW, Wateryoke respectively represent the temperature of end windings, slot

windings and the yoke of iron core of the stator of water-cooling motor, andWinEW□WinSW□Winyoke respectively represent the temperature of end windings, slot windings and the yoke of iron core of the stator of air-cooling motor. In the air-cooling motor,
the temperature of windings is higher than that of the iron core, and the temperature of slot windings is as same as that of the end windings, while in the water-cooling motor the highest temperature happens at the
end windings, and the temperature of the iron core is far lower than that of the windings. Above all, the results accord with theoreical analysis.

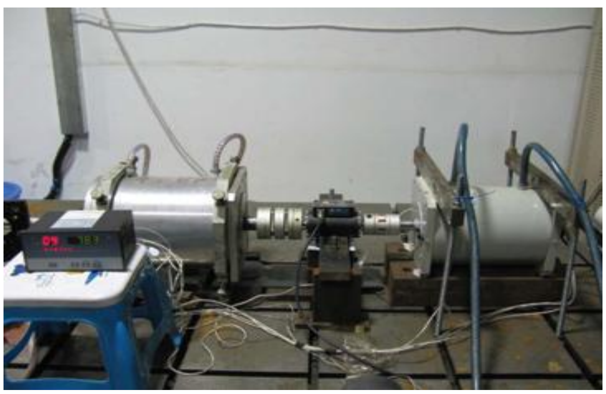

Fig.2 test of motor temperature

IV. Conclusions

By magnetic circuit calculation and numerical simulation, the effects of rotor materials and air gap length on the performance of different induction motors are studied. It shows that the efficiency of the motor with a copper cage rotor is 5% higher than that of the motor with a aluminum cage rotor. The air-gap
length has a great effect on the exciting current, which means as the air-gap length increases, the heat load and exciter current will increase. Hence, decreasing the air-gap length can help decrease the exciter current and improve the power factor, but it should be noted that to reduce gap length may bring difficulties to mechanical processing. For the motor with a processed air-cooling aluminum rotor and the motor with a copper rotor, the experimental results show that both the efficiency and the effective area of the latter motor are higher than those of the former motor. The numerical simulation and experiments also show that the temperature raise of the water-cooling motor is lower than that of the air-cooling motor.

References

[1] YU Rong-kai, LIU Fei, WEI Ke-kang, YOU Xiao-jie. Design of Motor Drive System for Series Hybrid Electrical Vehicle
Based on CAN Bus. Electric Machines & Control Application, 2008,35 (4):27-30,63.

[2] GUO Wei, ZHANG Cheng-ning**.** Iron losses and transient temperature analysis of the permanent magnet synchronous
motor for electric vehicles**.** Electric Machines and Control, 2009,13 (1):83-87,92.

[3] Liu R., Zheng P., Xie D., Wang L..Research on the High Power Density Electromagnetic Propeller. IEEE Transactions on
Magnetics, 2007,43(1) :355-358.

[4] WEI Yongtian□MENG Dawei, WEN Jiabin. Heat exchange in the motor. China machine press,1998:105-109

[5] Ruan Lin, GuGuobiao, TianXindong, Yuan Jiayi. The comparison of cooling effect between evaporative cooling method
and inner water cooling method for the large hydro generator Electrical Machines and Systems. International Conference on ICEMS,
2007, 8-11 Oct:989-992.

[6] KuosaMaunu, Sallinen Petri, LarjolaJaakko. Numerical and experimental modelling of gas flow and heat transfer in the air
gap of an electric machine.Journal of Thermal Science, 2004,13(3): 264-278.

[7] ZHOU Feng, XIONG Bin, LI Wei-li, CHENG Shu-kang**.**Numerical Calculation of 3D Stator Fluid Field for Large Electric
Machine as Well as Influences on Thermal Field Distribution**.** Proceedings of the Csee, 2005,25 (24): 128-132.