Parameter Matching of Open Winding Permanent Magnet Synchronous Motor Based on Performance Requirements of Electric Vehicle

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ABSTRACT
As the only driving source of pure electric car, the motor system is the top priority of research and development, so the efficiency of the motor directly affects the energy consumption of the whole vehicle. Among all types of motors, permanent magnet synchronous motor (PMSM) has attracted more and more attention because of its advantages in power factor and high efficiency. This paper starts from the purpose of applying the open winding permanent magnet synchronous motor to the whole vehicle. Firstly, the working characteristics of the open winding permanent magnet synchronous motor are analyzed, and the bench test is carried out to verify the working characteristics of the open winding permanent magnet synchronous motor, in order to ensure the accuracy of vehicle model simulation analysis based on open winding permanent magnet synchronous motor. At the same time, combined with the cycle driving condition analysis of pure electric car, the energy consumption rate under two typical working conditions is taken as the measurement index. Based on the completion of parameter matching of open winding permanent magnet synchronous motor, the vehicle model is established for economic simulation analysis to verify the economic advantages of open winding permanent magnet synchronous motor applied to the vehicle.

Keywords: *Vehicle Performance, Open Permanent Magnet Synchronous Motor, Parameter Matching, Bench Test*

1. PREFACE

The open winding permanent magnet synchronous motor is to open the neutral point of the traditional permanent magnet synchronous motor Y winding connection. Six leads at both ends of the neutral point are led out of the motor, and every three leads are connected with an inverter, which is equivalent to connecting an inverter on both sides of the motor, forming a dual inverter structure system. Compared with the traditional single inverter structure system, this structure system effectively reduces the number and scale of power switches. However, researchers mainly study the application of the system to AC induction motor, and the relevant information about the application of the system to permanent magnet synchronous motor is very few, so there is a broad space for the application of the system structure in permanent magnet synchronous motor.

1.1. Research Status Abroad

The research focus of foreign research is the theory of control strategy of open winding asynchronous motor in motor and Experimental Research on electric vehicle. In 1993, Stemmler and guggenbach proposed several high power open winding drive methods based on two-level or three-level inverter. This is the first published article on open winding drive. Two possible configurations are discussed in this paper: two inverters share one power supply or two inverters have their own power supply. For single power structure, a zero sequence current will be generated in the circuit. Therefore, the zero sequence current is needed to be suppressed in the open winding motor drive with single power supply structure. It is also pointed out that the voltage of the two inverters does not have to be the same. In addition, more voltage level inverters can be applied to both sides of the motor, so that better voltage waveform can be obtained.

Somasekhar and et al. studied the influence factors of zero sequence vector position driven by open induction motor. By arranging the zero sequence vector reasonably for each independent inverter, the zero sequence voltage on each motor winding can be reduced to zero. The disadvantage of this algorithm is to lose about DC bus voltage.

Professor Eric semail and Dr. n.k.nguyen analyzed the structure scheme of open winding motor with two different energy storage devices applied to pure electric vehicles. The control strategies adopted are the unit power factor control method, voltage integral control method and maximum voltage control method proposed

by welchko. Professor Eric semail and Dr. n.k.nguyen also simulated the proposed method, which is divided into six parts

Super capacitor power supply (2) battery supply, super capacitor charging (3) super capacitor power supply (4) super capacitor and battery power supply (5) super capacitor charging (brake energy recovery) (6) battery power supply, super capacitor charging. The results show that the above three methods can be used to realize the application of the open winding motor with double inverter in the pure electric car.

1.2. Domestic Research Status

Wu Di of China University of mining and technology studies the modulation strategy of open winding motor double ended cascaded five level inverter [1] , which mainly focuses on the problems of zero sequence voltage suppression, neutral point potential balance, dead time compensation, narrow pulse elimination and so on. Based on different modulation purposes, a variety of five level SVPWM modulation strategies are proposed.

Zhu XiaoCong of Harbin Institute of technology studies the direct torque control system of dual inverter open winding permanent magnet synchronous motor [3]. The main purpose is to study the SVPWM control strategy of dual inverter open winding permanent magnet synchronous motor. The direct torque control strategy is adopted to reduce the torque fluctuation caused by non-ideal back EMF, the other SVPWM control is combined in the whole control system to realize double closed-loop control of speed and torque.

2. PARAMETER MATCHING OF 2 OPEN WINDING PERMANENT MAGNET SYNCHRONOUS MOTOR

Permanent magnet synchronous motor (PMSM) has become the mainstream motor used in pure electric car, and open winding PMSM is a new type of motor, which represents a development direction of motor [2]. The open winding PMSM applied in the whole vehicle must be able to better meet the requirements of pure electric car for motor working characteristics.

2.1 Characteristic Requirements of Driving Motor based on Vehicle Performance Requirements

The demand for torque and power of driving motor of pure electric car is different under different actual running conditions. Therefore, combined with the actual operation conditions of pure electric car, the requirements for motor system are as follows: small volume, light weight, low price and high reliability High efficiency over the entire operating range. Low speed and high torque characteristics and wide range of constant power characteristics, even if there is no transmission, the motor itself should meet the required torque requirements.

2.2 Parameter Matching of Open Permanent Magnet Synchronous Motor

According to the basic parameters and power system parameters of a pure electric car model, the range of parameters of Y/ △ winding of open winding motor is preliminarily determined[4]. Then, the parameters of Y/ △ winding of open winding motor are calculated by genetic algorithm.

According to the formula and the basic parameters of the whole vehicle, the minimum power required by the maximum speed is 42.5kw, the minimum power required for the highest climbing slope is 49.3kw, and the minimum power required for acceleration time is 72.4kw. According to the power level requirements proposed by the national standard, the minimum power level requirements are set out in the national standard, The peak power of y-winding of the matched open winding permanent magnet synchronous motor is 75kW and 90kw in delta winding.

The limit of the maximum speed of open winding motor is the maximum speed and the ratio of main deceleration of the vehicle. When y-winding connection of open winding permanent magnet synchronous motor is considered [5], it is mainly used for the starting acceleration operation of the whole vehicle. Determine that the maximum speed of the motor when the y-winding is connected is 6900rpm. The maximum speed of delta winding of open winding motor is calculated from the maximum speed required by the whole vehicle. Because any speed value with speed greater than 10320rpm is OK, but the selected speed is not easy to be too large. Therefore, the maximum speed value of delta winding is 11400rpm.

3. BENCH TEST OF 3 OPEN WINDING PERMANENT MAGNET SYNCHRONOUS MOTOR

3.1 Steady State Test Scheme for Y-winding of Open Permanent Magnet Synchronous Motor

Open permanent magnet synchronous motor test mainly includes: external characteristics and part load characteristics test, efficiency interval test [6].

(1) External characteristic and part load characteristic test

During the test, the load motor is the speed control mode, and the tested motor is the torque control mode. Monitor can controls the loading torque command of the

tested motor. The bus input rated DC voltage of the motor controller under test is 165V. The actual output torque of the motor system under the same speed and different torque commands is tested [7]. The stable time of the working point is not less than 30s.

(2) Efficiency interval test

During the test, the load motor is set to speed control mode, and the tested motor is set to torque control mode. The speed setting of the load motor is consistent with that of the external characteristic test. The bus input rated DC voltage of the motor controller under test is 165V. Monitor can controls the loading torque command of the motor under test, tests the DC bus voltage and current of the motor controller under test, tests the constant torque characteristic of the motor whose speed is less than the base speed and the constant power characteristic of the motor whose speed is greater than the base speed [8], and the measuring points on the torque speed characteristic curve of the whole motor system are not less than 7 points. When the speed is 200 R / min, the torque test is omitted. In addition, close to the base speed, the speed range is set to 100r as a test point [9].

3.2 Analysis of Y-type Winding Test Results

It can be seen from the test curve that the torque curve of the tested motor is roughly consistent with the ideal external characteristic curve [10]. It shows that the open winding motor designed and selected according to the overall performance parameters of a certain vehicle is in line with the requirements, and can meet the performance requirements of an electric vehicle. The rationality of its structure and parameter selection is further verified.As show in Figure 1. [11].

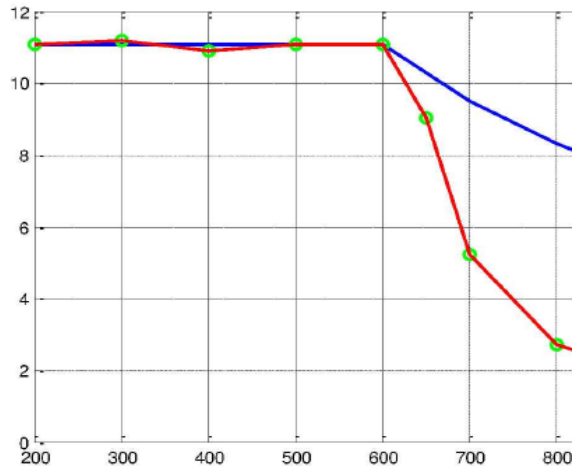

Figure 1. Test results of external characteristic curve of y-winding motor

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