Research on pure electric vehicle driving motor

Shuang Song*, Chao Sun, Cong Zheng, and Guicui Song
Zaozhuang Vocational College, Shandong, China

*Corresponding author e-mail: songshuang0210@163.com

Abstract. The current promotion of new energy vehicles, These include fuel cell vehicles, pure electric vehicles and plug-in hybrids. "Pure electric cars" are no stranger to today's people. It has many advantages. Such as good acceleration performance, high power, environmental protection and energy saving. It is very much in line with the changing demands of The Times for transportation modes. Because of the significant environmental and energy savings, In particular, there is no direct discharge of air pollutants during use. So there's a big push at the national level. In order to optimize the performance of the driving motor system of pure electric vehicles, Improve its efficiency, improve its structural design. Further research on vehicle driving motor.

1. Overview of motor drive system
At present, China's population, resources and environment have become bottlenecks. The concept of sustainable development and the use of new energy have been put on the government's development agenda. Automobile energy saving is an important topic. Improve the energy efficiency of cars, Reduce the emission of harmful substances from automobile exhaust, Using new energy sources, The ultimate goal of environmental protection has become an international practice. It is also the goal of developing automobile industry in China [1].

With the introduction of pure electric cars into millions of homes, Its driving motor and control system are also becoming a hot topic. We urgently need to realize the stable and reliable operation target of driving motor and control system in this field. Now, by doing a lot of research, A whole theoretical system has been formed in this respect. But there are still some areas that need further improvement. In the future, the driving motor and control system of pure electric vehicles will continue to improve with the continuous improvement of science and technology. Development prospects will be even broader.

1.1. Basic principle of drive motor.
The drive motor system consists of a drive motor and a motor controller. Driving motor is an important actuator of power system. Electrical and mechanical energy conversion components, It has the dual function of generator and motor [2]. The driving motor controller collects the rotation position of the motor. And the feedback current signal, Turn IGBT or MOSFET on and off control, To form a rotating alternating magnetic field, Thus the motor is controlled to operate according to the target torque and direction.

VCU issues various instructions according to the driver's intention, MCU responds and gives feedback, and adjusts the output of the driving motor in real time, so as to realize the functions of idle,
forward, reverse, parking, energy recovery and standing slope of the vehicle. Another important function of the MCU is communication and protection, real-time status and fault detection, to protect the drive motor system and vehicle safe and reliable operation.

Figure 1. Basic principle of drive motor.

2. Analysis of current situation of pure electric vehicle driving motor and control system

2.1. Requirements for driving motor and control system of pure electric vehicles
Unlike conventional cars, which run on gasoline or diesel, Pure electric cars are driven entirely by electricity. By driving a motor to move the vehicle forward, There are also some special features in the control system. So far, the driving motor and control system of electric vehicles are composed of many elements. They are: motor, controller, power electronic device, sensor and so on [3]. Among them, the main function of the driving motor is to convert the electric energy in the battery into mechanical energy. And by controlling the battery, Feedback the kinetic energy of the vehicle. The driving motor and control system of electric vehicles mainly involves the following contents:

First, drive motor requirements wide range of speed. The motor can operate in four quadrants.

Second, the drive motor and control system must take the torque as the control target. The torque must meet the requirement of fast and low fluctuation.

2.2. Development status of pure electric vehicle driving motor
After comparing several motors, We summarize the advantages and disadvantages of the four motors. As you can see, The overall evaluation of PMSM is the highest [4]. In practical applications, Ac asynchronous motor has low cost, stable performance, high reliability, flexible control method, good comprehensive performance and wide application.

Permanent magnet synchronous motor is a typical driving motor. It has the advantages of high efficiency, small volume and high reliability. It's the actuator of the power system. Electrical energy is converted into mechanical energy carrier. It relies on built-in rotary transformers, temperature sensors to provide information on the working status of the motor, And send the motor running state information to MCU in real time. The rotary transformer detects the rotor position of the motor, After being decoded by the motor controller internal rotatory decoder, The motor controller can know the current rotor position of the motor, Thus controlling the corresponding IGBT power tube conduction, The stator three coils are energized in order to drive the motor to rotate. The function of temperature sensor is to detect the temperature of motor winding, And provide information to the MCU, Then the MCU passes to VCU through the CAN line. Then control pump work, water circulation, cooling electronic fan work, Adjust the operating temperature of the motor.

2.2.1. Types and Performance of Driving Motors for ELECTRIC vehicles [1] A Comparison of the Performance of common driving Motors in electric Vehicles: Ac motors commonly used in electric vehicles are mainly asynchronous, permanent magnet and switched reluctance.
Its characteristics are shown in the table.

### Table 1. Comparison of main parameters of common motors.

|                               | De brush motor | Ac asynchronous motor | Permanent magnet synchronous machine | Switched reluctance motor |
|-------------------------------|----------------|-----------------------|---------------------------------------|---------------------------|
| **Power density**             | poor           | general               | good                                  | general                   |
| **Torque speed characteristic** | general       | good                  | good                                  | good                      |
| **Peak efficiency %**         | 85～89         | 90～95                 | > 90                                  | < 90                      |
| **Loading efficiency %**      | 80～87         | 85～92                 | > 85                                  | 78～86                     |
| **Speed range**               | 4000～6000     | 9000～15000            | 4000～15000                           | > 15000                   |
| **Operational ease**          | The best       | good                  | good                                  | good                      |
| **reliability**               | poor           | good                  | general                               | good                      |
| **The solidity of the structure** | poor         | good                  | general                               | good                      |
| **size**                      | big            | general               | small                                 | small                     |
| **The quality**               | heavy          | general               | light                                 | light                     |
| **The cost**                  | high           | low                   | high                                  | below Induction motor     |
| **Controller cost**           | low            | high                  | high                                  | general                   |

Among them, Asynchronous motors are mainly used in pure electric vehicles (including cars and buses). PMSM is mainly used in hybrid electric vehicles (including cars and buses). Switched reluctance motor is mainly used in bus at present.

### 3. Shortage and development trend of pure electric vehicle driving motor

**3.1. Areas to be improved in the current vehicle drive motor system:**

1) Full operating range of torque, speed control accuracy, efficiency optimization [5];
2) The reliability and durability of the system have not been fully verified, And the automobile industry's strict requirements have a certain gap;
3) The powertrain unit is of low integration, Degree of mechatronics is not enough;
4) Key materials (such as high-performance silicon steel sheet, insulation materials) and key components (such as IGBT module, CPU chip) are still dependent on imports, Limiting choice and cost reduction;
5) has not yet formed a complete, Supplier system that meets automotive industry standards. Although it has the ability to supply in small quantities, But the goods have not yet passed THE TS16949 quality system certification [6].

**3.2. Development Trend of electric vehicle motor drive system:**

1) Permanent magnetization of the driving motor. China has the world's most abundant rare earth resources, Therefore, high performance permanent magnet motor is an important development direction of vehicle drive motor in China.
2) High-speed driving motor, The feedback braking range is wide and efficient.
3) Drive motor control digitalization; The advent of dedicated chips and digital signal processors, It promotes the digitization of motor controller.

4) Drive motor system integration, And support the whole vehicle product serialization and the production scale;

5) There will be an independent supplier of new automobile electric drive system in China. Support for electric and traditional vehicle industries.

4. Selection of driving motor for electric vehicles

4.1. Electric vehicles have the following five basic requirements for driving motor system:

1) Output large torque below rated speed, In order to adapt to the vehicle starting, acceleration, load climbing and frequent start-stop and other complex conditions, Namely, constant torque operation;

2) Operate at constant power above rated speed, To meet the requirements of maximum speed and overtaking;

3) Efficiency optimization within the range of full speed operation, To increase vehicle mileage;

4) Strong structure, small volume, light weight, good environmental adaptability and high reliability;

5) Low cost and mass production capacity. Choose an electric motor for driving an electric vehicle. The following parameters of the driving motor should be considered:[7] Torque/speed characteristics, efficiency, Motor speed and control characteristics, cost, power density, structural strength, The fitness and maintenance of the working environment.

The performance of the drive motor directly determines the performance of the drive system. In electric cars, The selection principle of the driving motor is: [8]

1) High performance, low dead weight and small size;

2) High efficiency in a wide speed range;

3) Minimize electromagnetic radiation;

4) Low cost.

In addition, the selection of the driving motor should also consider the characteristics of its control system. Can realize two-way control, Regenerative braking regenerative energy. From the development trend, Traditional DC motors will lose competitiveness, The applications of switched reluctance motor and permanent magnet hybrid motor in electric vehicles have potential development.

5. Countermeasures and Suggestions for the development mode innovation of electric vehicle industry

5.1. Innovate the energy supply model, Improve the profit margin of the industry
Charging operators can change the traditional way of charging, Centralized battery management, maintenance and recovery, So that when consumers need to recharge their batteries, Directly exchange the rechargeable batteries in the charging station to continue on the road, That is, the innovative development USES the battery leasing operation mode under the mode of electrical conversion [9]. This innovative energy supply model not only makes it easier for consumers to avoid long waits, And consumers pay based on how much electricity they use, Can save a lot of expenses below the circumstance that price difference compares big in petrol electricity.

5.2. Improve the construction of supporting facilities
As the number of electric cars increases, The bus stations alone cannot meet the needs of more consumers, The transformation of parking spots can be carried out in concentrated areas of vehicle parking in the city. For example, parking lots in residential areas, shopping malls, and rail transit stations, The existing parking lot has been renovated, Parking lots that are not built or will be built incorporate charging facilities into their construction plans, Charging is different from parking, Buy with a credit card.
5.3. **Strengthen cooperation between industrial chains, Breakthrough technology Bottleneck**

The research and development of new energy vehicle core technology involves a wide range of technical fields. Such as machinery, chemistry, energy, materials, etc. It is impossible for enterprises to break through the technological bottleneck by relying on their own strength. The cooperation of the whole industry chain is needed. Automakers need to pump more money into core technologies, At the same time, We need to combine core component companies, financial institutions, infrastructure builders, university research institutions, energy enterprises and other forces. Jointly inject funds to strengthen cooperation [10].

5.4. **Innovate business development model, Meet the personalized needs of the market**

Enterprises can be based on individual, The approximate use of buses and taxis, Hierarchical production.

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**References**

[1] Haibo Chai, Zhiguo Yan, Mingwei Kuang, Jiandong Wu. Development Status of Electric vehicle Driving Motor [J]. Weite Electric Motor, 2013, 41 (4) :52-57.

[2] Ying Wang. Analysis of Common Driving Motors of Electric vehicles [J]. Science and Technology Association Forum, 2013, (3) :53-54.

[3] Mingming Gao, Jiafan Meng. Electric cars drive electric machine type selection analysed. http://d.wanfangdata.com.cn/Conference_7709331.aspx.

[4] Ke Song, Tong Zhang. Motor Drive System parameter matching of pure electric and tandem Hybrid electric vehicles [J]. Journal of Automotive Engineering, 2013, 35 (6) 559-564.

[5] C’edric Dusart, Pablo Gruer, Benjamin Blunier. Electric vehicle power systems: design approach based on modeling and simulation [J]. SEGULA TECHNOLOGIES, 2011 IEEE.

[6] Chunhua Xu, Jigao Niu,Fenglai Pei. Design and Simulation of the Power-train System for an Electric Vehicle978-1-4577-0536-6/11?2011 IEEE.

[7] K. Jaber, A. Fakhfakh, R. Neji. High level Optimization of Electric Vehicle Power-Train with Doehlert Experimental Design [J]2010 XIth International Workshop on Symbolic and Numerical Methods.

[8] AnDong Yin, Feng Yang, Hao Jiang. Power system matching and Optimization of pure electric vehicles based on ISIGHT [J]. Journal of Hefei University of Technology, 2013, 36(1):1-4. (in Chinese).

[9] Yifan Jian. Brief introduction to the driving motor and control system of pure electric vehicle. Ten-day issue of information Technology Era, 01, 2019.

[10] Chunying Dong, Derong Tan, Houjie Tian. Matching Simulation of Micro-pure electric truck Power system based on Cruise [J]. Journal of Shandong University of Technology (Natural Science edition),2013, 27(4) : 59-63. (in Chinese).