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The Driving Control of Pure Electric Vehicle

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Abstract

Pure electric vehicle has become the representative of new energy source auto because of its low level of environmental pollution, noise, high efficiency, availability of multiple energy resources, and ability of energy feedback. Pure electric vehicle is driven by motor, with no reduction gears in the scope of fixed torque and fixed power. It can also generate torque in the low speed scope, and can work under the way of fixed power using field-weakening control in the high speed scope. This paper analyzes the advantages and disadvantages of traditional drive mode, motor-driving axle combined drive mode, motor-driving axle integrated drive mode, and wheel-hub motor drive mode. The electric wheel driving vehicle gradually becomes a new direction of pure electric vehicle relying on its great advantage in the 4 driving modes.

Keywords: Pure electric vehicle; driving control; driving motor

1 Introduction

Automobile industry is the fundamental industry of national economy, it is closely related to peoples' life, and it has become an essential factor of modern society.

However, Although providing us fast and comfortable vehicles, traditional automobile industry consuming petroleum has already caused the economy's deep dependent on fossil energy resource and has made the conflict between energy production and consumption even worse.

24% of the world's total energy resource consumption is the vehicle energy resource consumption.

As the vehicle holding is still increasing, the energy resource problem becomes more and more obvious and threatening.

Moreover, the air pollution and global warming caused by CO2 has made a great influence on the environment in which we human beings are living.

In the circumstance of energy and environment crisis, increasing the efficiency of energy consumption and reducing the discharge of harmful waste are highly required.

However, it is very difficult to deal with this problem only by improving the performance of the engine. Developing new energy vehicles becomes the very direction of the development of automobile industry in the future.

Developing EV is one of the effective ways of solving this problem.

2 The Advantages of EV

Compared with ordinary engine driving vehicles, EV has the following advantages.

(1) High level of efficiency: the engine efficiency of modern vehicles is about 38%, while the ultimate efficiency is

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only 12% because of frequent braking, low speed driving and signal waiting. But EV suffers no lost of idles, and 80% of the e-power can transfer from motor into vehicle motion. Besides, it can retrieve power when braking.

(2)Low level of environmental pollution: Powered by batteries and super capacitors, pure electric vehicle discharges no waste gas.

(3)Low rate of noise: The noise and vibration of the automobile depends on the engine and the driving condition. Compared to engines, EV has much fewer vibration sources, no burning procedure, no mechanical motions, only has noises from air compressor, cooling fan and transmission mechanism. Thus its noise level is much lower than engine vehicles.

(4) Multiple energy resources available:

Not restrained by petroleum resource, EV can acquire e-power from public power grid. Thus any method to acquire e-power can apply to EV, such as hydro power, nuclear power, thermo power, wind power, subterranean heat and solar power.

(5) Energy feedback

According to the energy resource combination mechanism, we can easily retrieve the braking energy or potential energy when declining. Thus the continual mileage and the stability are going to increase. All the new EV developed in recent years have energy retrieving system, which can increase the continual mileage by 10%-15%.

3 The driving character of pure EV

3.1 The basic requirements of EV to Driving Control System

In an EV, motor is driven by the motor controller, the motor transfers the e-power into mechanical power to drive the vehicle.

The basic requirements of the EV to the driving control system are as follows,

(1)High specific power. To account in maximum power, usually reaches (1～1.25)kw/kg.

(2)Large range of motor speeding, usually in 25%-100% maximum speed, the motor may have a performance of small torque, permanent power, which can fulfill the requirement of the maximum speed and highway patrol of the EV.

(3)Sufficient starting torque to qualify the demand of fast starting, accelerating, climbing and frequent start/stop.

Usually the overload factor of the motor reaches 3-4.

(4)Fast torque response, the driving system can control the driving torque and braking torque quickly and mildly in all kinds of speed ranges; in multiple motor system, the motors should have high controllability, good steady state precision and dynamic characteristics.

(5)Good environmental adaptability, can do reliable work in harsh environments.

(6)High rate of energy retrieve in regenerative braking.

(7)Have good characteristics of efficiency, can acquire optimum efficiency in a wider speed/ torque range, increase the continual driving distance after charging 1 time, usually should acquire 85%-93% efficiency in typical circuit driving zone.

3.2 The dynamic characteristics of the motor

As to the traditional engine vehicle, the function of its engine is to transfer the heat energy into the rotating mechanical energy, which is transmitted to the wheels through gearing, differential and clutch. As the engine's maximum output torque changes with the speed change, the vehicle's speed should correspond with the switch of the reducer. In this way, the engine can keep working with a maximum power. However, pure EV are driven by the motors, which can generate torque in low speed range without switch the reduce gears, as shown in Figure 1. Besides, the motor can operate in permanent power in small torque by using the weakening control method. Thus pure EV can adopt these characteristics flexibly in different kinds of driving resources.

For example, to make the motor smaller and lighter, it is appropriate to put high speed motor and reducer together.

If the small, low speed and high torque motors can be put into practice, they can be installed directly on the wheels, to reduce the mechanical loss.

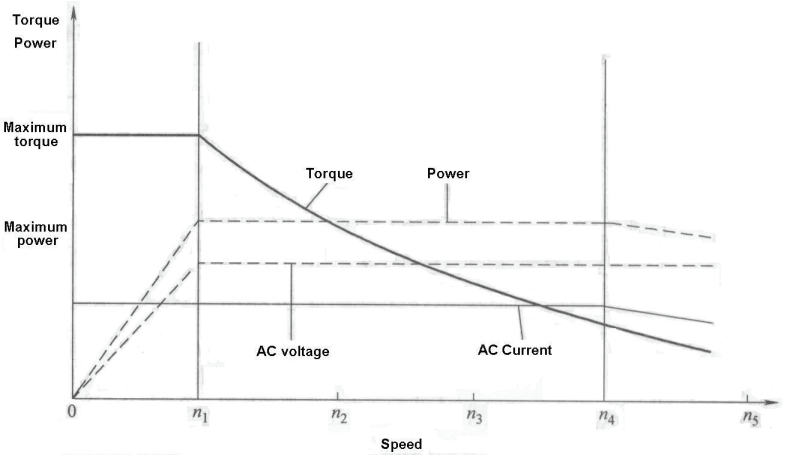


Figure 1 Dynamic characteristics of the motor

3.3 Choosing the motor's power

Motors have specific efficiency characteristics, that is, certain speed and power correspond to certain efficiency.

As the Pure EV energy resource is limited, we have to ensure that the motors operate in a high efficiency range, to get a high energy conversion efficiency.

The choice of motor power should not only satisfy a certain speed, but also operate under the condition of full load. The pure EV maximum speed must be satisfied, so that the vehicle can travel in a relatively high speed.

Pure EV is mainly applied as the civil transport device, in most conditions they travel in mid-low speed. Considering this situation, we should not choose high power motors; otherwise they will work under part load condition, which can make the motor efficiency much lower, thus waste the limited e-power. Given the expected maximum speed, the power value of the chosen motor should generally equals to but not be smaller than the power needed when traveling in the highest speed. That is:

$$P_{er} = \frac{1}{\eta_T}\left(\frac{Mgf}{3600}V_{max} + \frac{C_d A}{76140}V^3_{max}\right)$$

In the function above：Per is motor's rated power; M is the mass of the vehicle：g is acceleration of gravity：f is Rolling resistance coefficient; Vmax is maximum speed; Cd is air resistance coefficient; A is frontal area; ηT is the efficiency of power transmission system

4 The driving control of the Pure EV driving system

Compared with fuel vehicles, pure EV has a much more flexible structure, the energy of fuel vehicles is transmitted by rigid coupling and shaft. In pure EV, however, the energy is transmitted by flexible wires. Choosing and positioning EV parts is much flexible. To the traditional vehicles, the transmission box is an essential part. Choosing what kind of transmission box is the first consideration.

But it is totally different to pure EV. The torque and speed of the driving motor can be totally controlled by electrical controller,

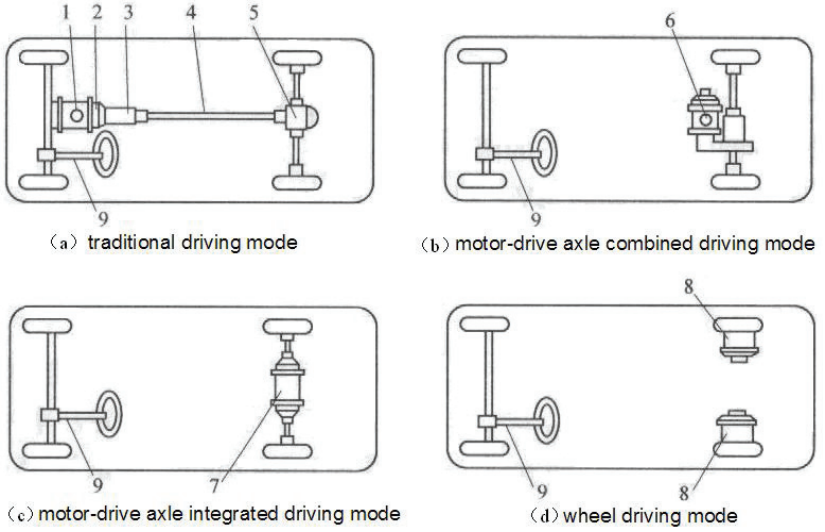
Thus we have multiple different choices when designing the transmission system.

Pure EV motor is very flexible, many kinds of motors can be applied as the EV driving motor, such as DC motor, AC motor and wheel motor.

Different types of energy storage, like batteries, fuel cells, super capacities and high speed wheels, can affect the EV weight, volume, length, thus affect the performance.

These different choices have made the design of the pure EV much flexible, and best choice guidelines are produced.

The driving modes of the pure EV include traditional driving mode, motor-drive axle combined driving mode, motor-drive axle integrated driving mode and wheel driving mode. See figure 2.



（a）traditional driving mode （b）motor-drive axle combined driving mode

（c）motor-drive axle integrated driving mode （d）wheel driving mode

1-motor; 2-clutch; 3-transmission; 4-transmission shaft; 5-drive axle; 6- motor-drive axle combined driving system; 7- motor-drive axle intergrated driving system; 8-wheel motor driving system; 9-steering

Figure 2 The drive mode of EV drive system

4.1 The traditional driving control of EV

In the early days of developing EV, most of the EV used traditional clutch-transmission-shaft-drive axle- wheel driving mode, that is traditional driving mode, as shown in Figure 4a.

The characteristics of the traditional driving mode are,

(1)Motors have replaced engines.

(2)Still use the transmission system of engine vehicles, including clutch, transmission, shaft and driving axle.

(3)Have various kinds of driving modes such as F-F, P-R.

(4)Complex structure and low efficiency, the motor's performance can not be fully applied.

4.2 The motor-drive axle combined driving mode

The motor-drive axle combined driving system is to install speed reducing gears and speed differential gears under the shell of the motor's output. The power drives the wheels through the two half axis on the left and the right. The shells of the motor, the speed reducer and the driving axle are jointed together, and their axis are mutually paralleled. Thus the whole driving system is becoming more compact. This kind of driving mode is shown in Figure 4b.

The characteristics of the motor-drive axle combined driving mode are,

(1) To install speed reducing gears and speed differential gears under the shell of the motor's output, and forms motor-drive axle combined driving system.

(2)Have various kinds of driving modes such as F-F, R-R.

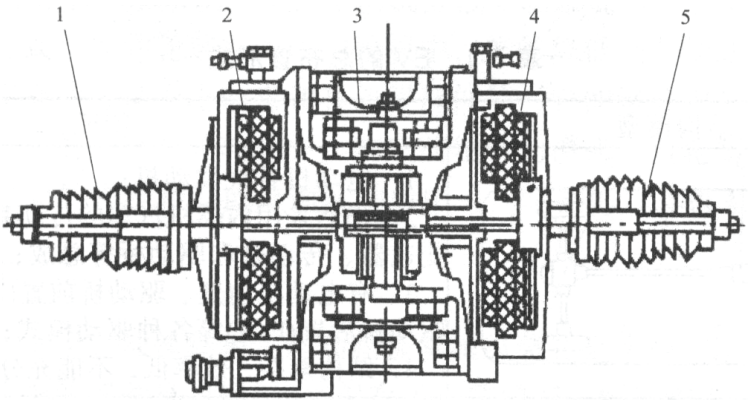
(3)It has compact transmission, high transmission efficiency and easy installation.

4.3 motor-drive axle integrated driving mode

The axis of motor-drive axle integrated driving system is a kind of hollow shaft specially manufactured. It has a compact structure, low volume, and can be devised under the EV frame.

The driving mode of motor-drive axle integrated is in Figure 4c.

The motor of this kind of driving mode can form integrated driving axis transmission system with twin motors. It removed the gears and totally realized "Mechatronics" as in Figure3.



1-left shaft; 2-left driving motor; 3-e-controlled differential; 4- right driving motor; 5- right shaft

Figure 3 Permanent magnet motor consisting of two dual-motor drive system

The characteristics of motor-drive axle integrated driving system are:

(1)Install gears and difference edge finders on the cover of the motor. The motor has a hollow shaft, and half of the driving shaft penetrates through it.

(2)Have various kinds of driving modes such as F-F, R-R.

(3)It has compact transmission, high transmission efficiency and easy installation.

4.4 wheel motor driving mode

The distributed driving system of wheel motor has completely separated from the traditional integrated driving mode of engine vehicles.

The motors are installed in the wheels, that is, electrical wheel driving. It can reduce the sprung mass of the vehicle, and can spare the space for the transmission to deploy the batteries and other parts.

This motor can be deployed in the two front wheels, two rear wheels or four wheels, forming front wheel driving mode, rear wheel driving mode or 4 wheel driving mode. The wheel driving mode is in Figure 4d.

The characteristics and advantages of the motor-drive axle integrated driving mode are,

(1)The clutch, transmission, shaft, differential and transmission systems have been removed and the mass of the whole vehicle has been significantly reduced, thus cutting the producing cost.

(2) Comparing with engine vehicles, the electrical driving vehicles have only a little magnetic and mechanical noise, thus greatly reduce the noise.

(3)The connection between electrical wheels and power source is flexible cable, which uses little space.

(4) After the electric wheel driving was applied, the full wheel driving technology is greatly simplified.

As to the full wheel driving vehicles based on electric wheel driving, it can freely switch the different driving modes, which can benefit the motor working in the high efficiency range. Because when the car is in good driving condition on the road, the power required is relatively small, so double motors driving can be applied. But in the acceleration, hill climbing and high speed conditions, we can start the all-wheel drive and maintain optimum power of the car. And the driving power of each wheel can be controlled real time according to the traveling status, thus practically realize the vehicle's "E-active chassis".

(5)Applying the retrieving system of braking energy on each wheel can greatly improve the energy usage. Comparing with single motor driving vehicle, its energy retrieve is much more.

(6)If 4WS technology is applied on the 4 wheel electrical vehicle, the performance of the vehicle steering will be realized, and reduce the turning radius effectively, even 0 turning radius, thus greatly increase the flexibility of steering

5 Conclusion

The driving system is the primary system of a pure EV.

The travel performance of pure EV depends on the performance of its driving system. The driving mode and configuration of the parameters will have a great impact on the pure EV. The recent domestic researches on the pure EV are based on the modified vehicles.

The modification of pure EV is a general mechatronics project.

The way to realize high performance after modification is not simply to replace the engine and gas tank with motor and battery.

It has to find proper battery, motor, transmission, speed reducer and control system and match them together. In the main program, they should have reliable connection and reasonable axle load distribution.

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