Design and Analysis of Transmission System of Pure Electric Vehicle

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Abstract:

The number of internal combustion vehicles continues to rise, which not only brings energy crisis, but also tail gas brings great environmental harm. At present, the new energy vehicle represented by pure electric has attracted the attention of all sectors of society. It not only effectively solves the problem of energy shortage, but also reduces the harm to the environment. This paper will briefly introduce the transmission system of pure electric vehicle, and analyze its evaluation indexes and design parameters, which is of great significance to establish the technology transformation strategy of pure electric drive.

Keywords:

Pure Electric Vehicle; Transmission System; Design Calculation and Analysis; Technology Transformation

1 Introduction

Climate warming, oil shortage and environmental pollution are the common challenges faced by the global automobile industry. Governments and the automobile industry have put forward their own development strategies to actively deal with them, so as to ensure the benign and sustainable development of the automobile industry chain and improve the international and market competitiveness in the future. Pure electric vehicle has become a hot spot in the development of automobile industry in the 21st century. Great wall, BYD, BAIC and other auto companies have launched pure electric vehicles one after another. Therefore, the research and analysis of pure electric vehicle transmission system design has important social significance.

2 Design and analysis of transmission system of pure electric vehicle

As the core drive system of pure electric vehicle, motor drive system is mainly composed of on-board battery module, control module and auxiliary module. The quality of motor drive system determines the power performance of pure electric vehicle.[1] At present, in the development of pure electric vehicle technology, the problems of high manufacturing cost, short service life and insufficient mileage of transmission system need to be solved urgently. Therefore, when optimizing the transmission system of pure electric vehicle, the following evaluation indexes should be met first:

2.1 Motor parameter design

In the motor parameter design, the main parameters considered include maximum speed and rated speed, rated voltage, rated power and peak power, maximum torque, etc.

2.1.1 Maximum speed and rated speed of motor

The maximum speed shall be designed according to the design requirements of the maximum driving speed of pure electric vehicle. The relationship between the maximum driving speed of electric vehicle and the maximum speed of motor is

$$n_{\max} = \frac{v_{\max} \Sigma i}{0.377 r}$$

$n_{\max}$ is the maximum speed of motor (R / min); $v_{\max}$ is the maximum speed of electric vehicle (km/ h); is the transmission ratio of transmission and main reducer; is the wheel radius (m).

The rated speed shall take into account the stable operation performance of the vehicle and the size of the power converter. The rated speed of the motor is

$$n = \frac{n_{\max}}{\beta}$$

n is the rated speed of the motor (R / min); $n_{\max}$ is the maximum speed of the motor (R / min); β is the expanded constant power coefficient of the motor, which is generally 2- 4.

2.1.2 Rated voltage of motor

The rated voltage of the motor is directly proportional to its rated power. The greater the rated power, the greater the rated voltage. The selection of rated voltage of motor is related to the voltage of battery pack of the whole vehicle. Therefore, it is necessary to select the appropriate battery pack current and voltage to meet the needs of the whole vehicle.[2]

2.1.3 Motor rated power and peak power

As the power source of the whole electric vehicle, the greater the power of the motor, the better the power of the whole vehicle. However, if the power is too large, the volume and mass of the motor also increase, which reduces the working efficiency of the motor and can not make full use of the on-board energy, so as to reduce the driving range. Therefore, the motor power parameter design should refer to the maximum climbing slope, acceleration capacity and maximum speed.

(1) Designed according to the maximum climbing gradient of electric vehicle

The power required for a pure electric vehicle to climb the maximum slope at a certain speed is

$$p_1 = \frac{v_p}{3600\eta}(mf\cos\alpha + mg\sin\alpha + \frac{C_D A v_p^2}{21.15})$$

(2) Designed according to the acceleration performance of electric vehicle

The power required for the electric vehicle to accelerate on a horizontal road is

$$p_2 = \frac{v_f}{3600\eta}(mgf + \frac{C_D A}{21.15}v_f^2 + \delta ma)$$

(3) Designed according to the maximum speed of electric vehicle

The power required for the electric vehicle to run at the maximum speed is

$$p_3 = \frac{v}{3600\eta}(mgf + \frac{C_D A v^2}{21.15})$$

v_p is the driving speed during climbing (km / h); η is the efficiency of mechanical transmission system; m is the vehicle mass (kg); f is the rolling resistance coefficient; α is the maximum slope angle; C_D is the windward resistance coefficient; A is the windward area (); v_f is the speed after acceleration (km/h); g is the gravity acceleration; δ is the conversion coefficient of vehicle rotating mass; P_e is the acceleration; $P_{e\max}$ is the maximum driving speed (km/h)

The rated power of the motor shall meet the requirements of the maximum speed, and the peak power shall meet the requirements of the maximum speed, acceleration and maximum climbing gradient. Therefore, the rated power and peak power of electric vehicle motor are

$$P_e \geq p_3$$

$$P_{e\max} \geq \max(p_1, p_2, p_3)$$

2.1.4 Maximum torque of motor

The selection of the maximum torque of the motor needs to consider the maximum transmission ratio of the transmission system, which is determined according to the maximum climbing angle and starting torque of the vehicle.

$$T_{\max} \geq \frac{mg(f\cos\alpha + \sin\alpha)r}{\eta i_{\max}}$$

$i_{\max}$ is the maximum transmission ratio.

3 Transmission ratio design of transmission system

When the motor output characteristics are constant, the transmission ratio of the transmission system depends on the dynamic indexes such as the maximum climbing slope, acceleration capacity and the maximum expected speed of the pure

electric vehicle.[3]

3.1 Lower limit of transmission ratio of transmission system

The lower limit of the transmission ratio of the transmission system is determined by the driving resistance corresponding to the maximum climbing gradient and the maximum output torque of the motor

$$i_{\max 2} \geq \frac{r}{\eta T_{\max}}(mgf\cos\alpha + mg\sin\alpha + \frac{C_D A v_f^2}{21.15})$$

The lower limit of the transmission ratio of the transmission system is determined by the driving resistance corresponding to the maximum driving speed and the output torque corresponding to the maximum speed of the motor

$$i_{\max 1} \geq \frac{r}{\eta T_{v\max}}(mgf + \frac{C_D A v^2}{21.15})$$

$T_{\max}$ is the maximum output torque ($N \cdot m$) of the motor; $T_{v\max}$ is the output torque ($N \cdot m$) corresponding to the maximum speed of the motor.

The lower limit of the transmission ratio of the transmission system is determined by the maximum value of the above method.

$$\sum_{\max} i \geq \max(i_{\max 1}, i_{\max 2})$$

3.2 Upper limit of transmission ratio of transmission system

The upper limit of the transmission ratio of the transmission system is determined according to the maximum driving speed and the maximum speed of the motor.

$$\sum_{\min} i \leq \frac{0.377 n_{\max} r}{v}$$

4 Summary

To sum up, in order to reduce the harmful gases produced by fuel vehicles and improve the climate warming caused by energy consumption, pure electric vehicles are bound to become a development trend. As an important part of pure electric vehicle, the performance of transmission system is related to the overall performance of pure electric vehicle. Therefore, we should constantly apply new structures, new materials and new technologies to improve the transmission system of pure electric vehicles, optimize the transmission system structure and transmission efficiency on the basis of improving its service life and performance, and further promote the development of electric vehicle technology.

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