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ASSESSMENT OF MOTOR AND BATTERY SELECTIONS FOR ELECTRIC VEHICLE DEVELOPMENT

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Abstract: Efficient electric vehicle design hinges on the precise calculation and selection of driving motors and power batteries. This study delves into the meticulous analysis of these crucial components, utilizing the fundamental parameters of electric vehicles presented in Table 1 as a reference point. By considering the specific requirements and characteristics of the electric vehicle, this research offers insights into the methodical process of determining the optimal driving motor and power battery, ensuring that the vehicle's performance and energy storage capacity align harmoniously with its intended application.

Keywords: Electric Vehicle Design, Driving Motor Selection, Power Battery Calculation, Electric Vehicle Parameters, Energy Storage Capacity

Introduction

In the design of electric vehicle, the calculation and selection of driving motor and power battery is one of the most important design contents. Based on the basic parameters of electric vehicle shown in the following table, this paper makes a detailed analysis on the calculation and selection of driving motor and power battery of electric vehicle in the Table 1.

Table 1: Main parameters and design goals of vehicles

Parameter name	Value	Parameter name	Value
Length, width and height;mm	2488*1506*1670	Maximum cruising mileage;km	200
Axle moment;mm	1600	M0;curb weight (kg)	840
Front wheel moment;mm	1310	Me; load mass (kg)	150
		M; Full load mass (kg)	990
Rear wheel moment;mm	1320	g; acceleration of gravity	9.8
Minimum ground clearance;mm	180	i ;Total speed ratio	16.3
Umax1;maximum speed (km/h)	80	A; windward area (m2)	2.244
Umax2;highest lasting Speed (km/h)	60	η;Transmission efficiency	0.9
Uc; conventional cruising speed (km/h)	40	R;tire radius (m)	0.306

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F;Rolling resistance coefficient	0.016	α_{max};Maximum grade	20%
t1;0-40km/h acceleration time (s)	10	t2;40-80km/h acceleration time (s)	10
Cd;wind resistance coefficient	0.8	δ;Rotating mass conversion factor	1.06

1. Model selection of the drive motor

In order to ensure that the electric vehicle for the elderly has good power and economy, it is necessary to carry out reasonable calculation and matching selection of the motor. The matching of electric vehicle drive motor mainly considers the performance indexes such as power, torque and speed.

Referring to the knowledge of automobile theory [1], the performance indexes are calculated and analyzed as follows:

2.1 Rated power

Rated power: refers to the maximum power required under the condition of continuous operation of the equipment and ensuring the specified indicators[2].

(1) The rated power must meet the maximum stable speed (maximum stable speed 60km / h):

According to the driving requirements of electric vehicles, the rated power of the motor is generally selected according to the maximum stable speed of the vehicle during uniform driving on a flat road. Namely:

$$P_e = \left(mgf + \frac{u_{max}\, C_d A u_{max}^2}{21.15}\right) \frac{1}{3600\eta} \quad (1)$$

Where: Pe - rated power of motor (kw); Umax – maximum speed (km / h); m - total mass of vehicle under full load (kg); g - gravitational acceleration (m/s^2); f - rolling resistance coefficient; Cd – air drag coefficient; A - windward area (m^2); η— transmission efficiency

Substitute the value in table 2-1 into the above formula for calculation:

$$P_e = \left(990 \times 9.8 \times 0.016 + \frac{0.8 \times 2.244 \times 60^2}{21.15}\right) \frac{60}{3600 \times 0.9} = 8.533(kW)$$

(2) The rated power must meet the stable climbing speed

$$P_a = \left(mgf\cos\alpha_{max} + \frac{C_d A u_i^2}{21.15} + mg\sin\alpha\right) \frac{u_i}{3600\eta} \quad (2)$$

Where: Pa - rated power of motor (KW); Ui– climbing speed (km / h); α— Climbing slope;

The rated climbing speed of 40km/h the vehicle is 12% (6.8°), The rated power is calculated as follows:

$$P_a = \frac{40}{3600 \times 0.9}\left(990 \times 9.8 \times 0.016 \times \cos 6.8 + \frac{0.8 \times 2.224 \times 40^2}{21.15} + 990 \times 9.8 \sin 6.8\right) = 17.747$$

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(kW) Through the calculation of the above two items, the maximum rated power is taken 17.747 kW.

2.2 Rated speed and driving power of straight road

Minimum normal driving power: refers to the working condition that the vehicle runs in a straight line at a constant speed of rated speed (40km / h) on a straight road, Required motor output power P_c. Equation (3) can be used for calculation:

$$P_e = (990 \quad 9.8 \quad 0.016\times \times \quad + \quad) = 3.578(kW) \quad (3)$$

$$\frac{40}{3600\times 0.9} \qquad \frac{0.8\times 2.224\times 40^{2}}{21.15}$$

2.3 Peak power

Peak power: refers to the maximum power that can be achieved in a short time as long as the basic functions are met, regardless of whether other quality indexes of the equipment can be achieved[3].

(1) The peak power shall meet the maximum power of the maximum speed of 80km / h, which can be calculated by substituting the formula (4), The numerical calculation results are as follows:

$$P\text{max}1 = (9909.8 \quad 0.016\times \times \quad + \quad) = 17.126(kW) \quad (4)$$

$$\frac{80}{3600\times 0.9} \qquad \frac{0.8\times 2.244\times 80^{2}}{21 .15}$$

(2) The peak power shall meet the maximum climbing gradient (20%, 11.3 °), which can be calculated by substituting the formula (2) into the numerical value:

$$P_{\text{max}2} = (990\times 9.8\times 0.016\cos 11.3^{\square\square} + 0.8\times 2.224\times 40 + 990\times 9.8 \sin 11.3) = 27.$$

$$\frac{40}{3600\times 0.9} \qquad 2 \qquad \frac{0.8\times 2.224\times 40}{21.15}$$

011(kW)

(3) the maximum power that meets the acceleration time T within 10s when the vehicle speed is from 40 to 80km / h can be calculated according to the following formula:

$$P_t = \frac{u^t}{3600\eta}\left(mgf + \frac{C^d A u^t}{21.15} + \delta\cdot \frac{u^1 - u^0}{3.6t}\right) \quad (5)$$

The numerical calculation results are as follows:

$$P_{\text{max}t} = (990 \quad 9.8 \quad 0.016\times \times \quad + \quad +1.06\times) = 17.155$$

$$\frac{80}{3600 \quad 0.9} \qquad 2 \qquad \frac{80 \quad 40}{6 \quad 10} \qquad 0.8\times 2.224\times 80 -$$

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× 21.15 3. ×

The value is the maximum value among P_{max1},P_{max2},P_{maxt}(17.126, 27.011, 17.155), and the maximum value is multiplied by safety factor 2 as the peak power, that is 54.022.

2.4 Peak torque

(1) The peak torque shall meet the requirements of the maximum climbing gradient (the maximum gradient is 20%, 11.3 °):

$$T_{max} = \frac{(mgf\cos\alpha_{max} + mg\sin\alpha_{max})r}{\eta i} \quad (6)$$

Where: Tmax -- peak torque (nm); r - wheel radius (m); i - total speed ratio; η— transmission efficiency Substitute the value in Table 2-1 for calculation:

$$T_{max} = \frac{(990\times9.8\times0.016\cos11.3^{\circ}+990\times9.8\sin11.3^{\circ})0.306}{0.9\ 16.3} = 50.388\ (Nm)$$

(2) The peak torque shall meet the acceleration time: the speed from 0 to 40km/h is uniform acceleration, and the time required is 10s.

$$Tu_{max} = \frac{C_D A u_m^2 t_m}{21.15\ 2} + (mgft_m + \delta mu_m + \times)\cdot r \quad (7)$$

Where: t_m - time required for acceleration (s); δ— Conversion coefficient of rotating mass; Um - acceleration target speed (km / h); r - wheel radius; I - total speed ratio; η— transmission efficiency Substitute into numerical calculation:

$$Tu_{max} = \frac{0.8\times2.224\times40^2\ 10}{21.15\ 2} + (990\times9.8\times0.016\times10+1.06\times990\times40+\times)\times0.306 = 92.199$$

$$16.3\times0.9\times10$$

Nm

After calculation, the peak torque is taken the maximum value in Tmax,Tuma,that is 92.199Nm

2.5 Maximum speed and rated speed

The maximum speed and rated speed of the motor are determined according to the maximum speed of the vehicle and the normal speed

$$\frac{0.77\times N\times r}{i} u_a = \quad (8)$$

Where, ua -- vehicle running speed (km / h); N -- motor speed (RPM); r -- wheel radius (m); i -- total speed ratio; Substitute into numerical calculation:

Rated speed: $40 = \frac{0.77\times Ne\times0.306}{16.3} \Rightarrow ne=2794.565(rpm)$

Maximum speed:$80 = \frac{0.77\times N^{max}\times0.306}{16.3} \Rightarrow n_{max}=5589.130(rpm)$

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16.3
Rated speed: 40 = 0.77×*Ne* ×0.306 => ne=2794.565(rpm) 16.3

0.77× N^{max} ×0.306 max=5589.130(rpm)
Maximum speed:80 = => n

16.3

2.6 Rated torque

Rated torque: the rated torque is determined according to the rated power and rated speed of the motor

$$T_e = \frac{9550P^e}{n\ e} \quad (9)$$

Where, Te -- rated torque of motor (Nm); Pe -- rated power of motor (kw); ne -- rated speed of motor (rpm);
Substituting into the numerical calculation, the rated torque is:

$$T_e = \frac{9550 \times 17.8}{2794.565} = 63.377(\text{Nm})$$

Summarize the above calculations to the following table the Table 2

Table 2: Basic parameters of drive motor

parameters of drive motor	**Calculation results**	**Value**
P_e-Rated power (kW)	17.747	20
P_c - rated speed and driving power of straight road (kw)	3.578	3.6
P_{max}-peak power(kw)	54.022	55
T_e-Rated torque(Nm)	63.377	65
T_{max}-Peak torque(Nm)	92.199	100
N_e-Rated speed (r/min)	2794.565	3000
N_{max}-Maximum speed (r/min)	5589.130	6000

3. Selection of power battery

3.1 Maximum power output of battery

During the driving process of electric vehicle, the output power of power battery is greater than or equal to the sum of the input power of power motor and the input power of on-board electrical equipment. From the parameter calculation and analysis of the motor in the previous section, the peak power of the motor is 55kW. Generally, the total power of the whole vehicle electrical equipment (including air conditioning) is about 1.5KW. It can be calculated that the peak power demand of the power battery output is 56.5kw, that is, the maximum power output of the battery.

3.2 Total storage capacity of power battery

The total storage capacity of the power battery is directly related to the vehicle's once fully charged mileage. If the design of the total storage capacity of the battery is too small, the mileage is too small, which will affect the performance of the vehicle; The design of the total storage capacity of the battery is too large, which increases the manufacturing cost and the total weight of the vehicle. The electric vehicle for the elderly designed in this

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subject is mainly driven on urban roads and meets the needs of the elderly to and from a city. Therefore, the designed comprehensive mileage of the vehicle is 100km.

The power of the driving motor is 3.578 (kw) when the vehicle runs at the rated speed of 40km/h on a straight road; The power of the driving motor is 17.747kw when the climbing slope is 12% (6.8°) at the rated speed of 40km/h; The total power of electrical equipment (including air conditioner) of the whole vehicle is about 1.5 kW[4]. From the perspective of parameter conservation, the total storage capacity of power battery can be calculated by the following formula:

$$E\xi\eta\eta\eta q \qquad m = (Pmotor + Pdivice) \cdot \frac{L}{u\ e} \qquad (10)$$

Where:

E is the total energy of power battery (kw·h); ξ Is the discharge depth of the battery. In order to protect the power battery and avoid excessive discharge of the battery, take 0.8; η_q is the battery discharge efficiency, taken as 0.95; η Is the transmission efficiency of vehicle power system (Table 2-1); η_m is the efficiency of the motor in converting electric energy into mechanical energy, taken as 0.9; P_{motor} is the power of the driving motor (kw); P_{divice} is the total power consumption of electrical equipment of the whole vehicle (kw); L is the endurance mileage of the vehicle under rated working conditions (km); u_e is the rated speed (km/h);

When estimating the comprehensive endurance mileage of automobile in the city, it can be roughly calculated according to the situation that straight roads account for 70% and other complex road conditions account for 30%. In order to simplify the calculation, the power consumption of these 30% complex road conditions is calculated according to the power consumption of automobile at the rated speed of 40km / h and the climbing slope of 12%. The detailed calculation is as follows:

$$E\times0.8\times0.95\times0.9\times0.9 = (3.578 \quad 1.5) + \frac{100\times70\%}{40} \times (17.747 + \quad 1.5+) \times \frac{100\times30\ \%}{40} =>$$

E=37.885(kw·h)

Through the above calculation, it can be seen that the total storage capacity of the designed power battery should be 38 ((kw·h)

4. Conclusions

Based on the specified basic parameters of the electric vehicle, this paper makes a detailed calculation and Analysis on the key parameters of the motor such as the rated power, minimum normal driving power, peak power and peak torque of the driving motor of the electric vehicle, and finally obtains the parameter table of the driving motor, according to which the driving motor can be selected and configured. At the same time, this paper also makes a detailed calculation and analysis of the maximum power output of the power battery and the total storage capacity of the power battery, which provides a theoretical reference for the selection and matching of the power battery.

Acknowledgement

Research project: 1). 2022 Basic Research Capability Promotion Project for Young and Middle-aged Teachers in Guangxi Higher Education Schools "Research on Automatic Positioning System for Wireless Charging of Automobile Based on Maritime Search and Rescue Algorithm", No. 2022KY1335

2). Research results of the high-level innovation team of new energy automotive electronics technology in Guangxi Electrical Polytechnic Institute, No. GEPI [2020] 268

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