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# Design of research and development on golf car

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## ABSTRACT

The golf car is an electric and environmentally friendly passenger vehicles what been designed and developed for the golf stadium. In the paper, the selection of the motor and battery, transmission device, drive axle, steering system, brake system and so on have been analyzed in detail. And the corresponding parameters of the golf car have been checked to make a design to meet the needs of the body.

## KEYWORDS

Golf; Electric cars; The motor; Transmission system; Braking system.



## INTRODUCTION

The golf car, also known as electric golf car, is an environmental and friendly passenger vehicle what has been designed and developed for the golf stadium. The consumer groups of the golf stadium are mainly the upper class with high quality and high consumption. A comfort, environmental golf car whose structural design was reasonable, can meet their spirit enjoy in the material consumption.

## RELATED DESIGN CALCULATION AND THEORETICAL BASIS

### Selection of the motor

The vehicle traction motor of high density, high efficiency, and wide speed range and control system are the heart of the electric car. It is also one of the key technologies of the electric car development. This has been listed as 863 the common key technology project of electric cars. To choose the suitable motor, firstly the power what the electric cars need should been known. Motor power calculation formula was as follows. The total weight of the electric car was estimated, the following for verification.

$$P_e = \frac{1}{\eta_T}\left(\frac{Gfu_a}{3600} + \frac{C_D A u_a^3}{76140}\right) \quad (1)$$

In the formula: $\eta_T$: Mechanical efficiency (Taking 0.92); G: The total weight of electric vehicles, N; f: Driving resistance coefficient of electric vehicles on good road, (taking0.015); $u_a$: speed of electric vehicle, km/h; $C_D$: The air drag coefficient (taking 0.5); A: The windward area of electric cars ($m^2$).

To the total weight for the design of the electric car, the total mass has been estimated 1300 kg, which was 12740 N.

The top speed to the design requirements was 25 km/h

The windward area of the electric car A = width of the car×height of the car

Width of the car was 1200 mm; Height of the car was 1810 mm.

So, A = 1200×1810 = 1810 =2172000$mm^2$=2.17$m^2$

Into the data calculated by the (1) :

$$P_e = \frac{1}{\eta_T}\left(\frac{Gfu_a}{3600} + \frac{C_D A u_a^3}{76140}\right) = 1.70\text{kW}$$

By the above it can been known that the power of the motor was at least 1.70 kW. But the choice of motor power must be bigger. As a result, the brushless permanent magnet synchronous motor what been choose, its parameters were as follows:

Model: ZY-CD-2.5; Rated power: 2.5kW; Peak power: 4.5kW; Rated voltage: 48V; Rated current: 60A; Maximum torque: 150 Nm; Rated speed: 1100 r/min; The highest speed: 2000 r/min; Insulation class: F; Protection grade: IP54; Cooling method: natural air cooling; Weight: 50 kg; Appearance size: Ø216 ×340.

### The selection of the battery

At present, the lead-acid battery is most commonly used to electric cars on the market. The Lead-acid battery is not only one of the most mature technologies, but also the cost of the battery is lowest. Considering the cost and the actual performance of the electric car, the lead-acid electromagnetic has been decided to use as the electric power supply. The voltage of battery is decided by motor, and the capacity is determined by the driving range of electric cars. In the paper, the driving range of electric cars has determined the capacity of the battery. According to design requirements and the known conditions, driving range of electric cars was 60 km, the top speed was 25 km/h. The motor power was 2.5 kW.

So travelling time of the electric car was:

$$t = S / u_t = 60 / 25 = 2.4h$$

The battery capacity of the electric vehicle should be followed:

$$R = P \times t / u_a = 2500 \times 2.4 / 48 = 125Ah$$

From the above calculation, it has been shown that the capacity of the battery was at least 125 Ah. In the design, the 200 Ah lead-acid battery has been selected. The specific parameters of the battery were as follows:

Rated voltage: 24 V

Nominal capacity: 200 Ah
Appearance size (mm) : length×width×height = 520×240×220
Total height (mm) : 255
Weight: 73 kg
Each battery voltage is 24 V, and motor rated voltage was 48 V, so two such batteries were used as driving motor.

**The decorating form of the transmission system and selection of drive axle**

**Classification of the decorating form of the transmission system**

The decorating forms of chassis power are mainly front engine front wheel drive, front engine rear wheel drive and rear engine rear wheel drive. A few cars are using the engine front all-wheel drive.

**The front power supply and front-wheel drive**

Compared with the rear wheel drive, the front axle shaft load to front wheel drive is big, and Its steering performance is not good; Because the front wheel is driving wheels, the ability to cross obstacle is high; Because there is no transmission shaft, the convex hull height of the car floor can reduce, and it is favorable to improve ride comfort; When motor has been installed outside the wheelbase, the wheelbase can be shortened, thus it is favorable to improve the maneuverability of vehicle; the dissipation heat condition is good, the motor can get enough cooling; the Suitcase is decorated in the back of my car, so there is enough luggage space; And the influence of such factors such as the drive shaft has been cancelled, the consumption materials of the car has been decreased significantly, and the whole the quality has been reduced. Its disadvantages are that a patterned constant speed universal joint has been required in the front wheel drive and steering, its structure and manufacturing process are complicated; the load of the front axle is heavier than rear axle, and the front wheel was steering wheel, so the working conditions of the front wheels is bad, tire life is short; Uphill the adhesion of the drive wheels is reducing, the gradeability reduced; Once the head-on collision accident happens, the loss of motor and its attachment is bigger, the cost of maintenance is high[1].

**The front power supply and rear wheel drive**

The axial load distribution is reasonable, thus to improve the service life of tires; The front wheel doesn't drive, and thus it needn't to use constant speed universal joint, and it is favorable to reduce manufacturing cost; Operation is simple; The motor cooling conditions are good; Uphill, because the adhesion on the drive wheels are increasing, the climbing ability is strong; There is enough luggage space. Its shortcomings are following because there is shaft under the floor, there is convex on the floor, and it makes the rear seat cushion thickness thinning of central to affect the ride comfort; When the car head-on collision with other objects, it is easy to cause the motor into the passenger compartment, and to make the front occupant badly hurt; The car body is longer and the vehicle equipment quality is increasing, at the same time the economy and power performance of the car are affected.

**The rear engine and rear wheel drive**

For the car of the rear engine rear wheels drive, the motor and main reducer layout as a body. Besides the structure is compact, it has the following advantages: Because of the rear of the motor, the front height can be conditionally lower to improve the driver's field of vision; the vehicle equipment quality is small; the space of the transmission shaft is small, so the floor is flat, the lower convex hull is needed to accommodate the operating mechanism and strengthen the floor stiffness, and passenger seat can be decorated in the comfort zone; when traveling on the ramp, because the adhesion of the drive wheels is increasing, climbing ability has been raised; the motor has been installed outside the wheelbase, the wheelbase is short, and motor performance is good. Its main drawbacks are that the rear axle load is heavy, and make the car over steer tendency; the front wheel adhesion is small, when the car speeding, the steering is not stable, and the steering stability is affected[2].

By the actual analysis of the appeal scheme, in the design, the most suitable scheme of the transmission system was after the rear drive: the rear motor rear wheel drive. When the rear engine was used, the front axle was not easy to overload and the trunk area can be more fully used, the body height also can effectively be reduced, or the space under the floor in the middle of electric vehicles can be made full use to put the baggage, the impacts of noise and high temperature of engine on the driver can also be reduced. And the speed and stability of the car on the golf stadium have been required lower. Electric vehicle drive system was power transmission system; it was similar with hydrostatic transmission system of fuel automobile. In this paper, after the rear drive was used, clutch and transmission can also be saved to greatly simplify the whole transmission system, also to reduce the weight of vehicles at the same time, to improve the dynamic performance of the electric vehicles. The front can be reduced to give the passengers a broader perspective.

**The selection of drive axle**

Drive axle casing is one of the main bearing components on the car, is at the end of the power transmission system, its function mainly has: supporting and protecting the lord reducer, differential and half shaft and etc., and making the axial position of the drive wheel fix; with driven bridge support frame and the assembly quality. When the car driving, drive axle bear the reaction force and torque from wheel to the pavement and the suspension to the frame, etc. Drive axle casing was divided into integral bridge shell, sectional bridge shell and combination bridge shell. One-piece axle casing has great

strength and rigidity, and was convenient to assembly, adjustment and maintenance of main reducer, so it was widely used in all kinds of car[3].

In the design, the independent suspension has been adapted to the front and rear wheels of the electric vehicles, a leaf spring of independent suspension has been adapted to the rear axle, so the rear axle what selected was integral. But in order to ensure that electric cars have good maneuverability, the McPherson suspension has been used to front axle, the front axle was steering axle and the rear axle was driving axle. The drive axle casting was a hollow beam connecting left and right driving wheels, and the main reducer, differential and wheel gear have been packed in it.

**Selection of steering system**

**Steering system**

The steering system is used to maintain or change the car driving direction, and when the car is driving, the angle relationship of coordination between the steering wheels can be ensured.

Mechanical steering system relies on the driver's hand to turn the steering wheel, and makes the steering wheel deflection by steering and steering transmission mechanism. The injury prevention mechanism and steering damper have been equipped to some cars. The power steering car is equipped with power system, and with the help of this system to reduce the driver's hand. The application of mechanical steering is more. According to the structure characteristics, the mechanical steering can be divided into gear and rack steering, circulating ball steering, worm roller steering and worm pin steering, etc.

**The gear and rack steering**

The gear and rack steering consists of steering gear with steering shaft and rack associating with the tie rod. Compared with other forms of steering gear, the main advantages of gear and rack steering are following as: the structure is simple and compact; the shell is adopted aluminums alloy or magnesium alloy die casting, the quality of the steering is small; the transmission efficiency is as high as 90%; because of a gap between wear gear and rack, clearance can be automatically eliminated by the spring of the adjustable compression force in the back of the rack and near the active pinion, this not only can improve the stiffness of steering system, but also can prevent the impact and noise at work; the volume of the steering is small; No steering arm and straight rod, so the angle of the steering wheel can increase; manufacturing cost is low[4]. according to the different position of the input gear and output characteristics, the gear and rack steering has four forms: intermediate input, output at both ends; both ends of side input, output; profile input, intermediate output; profile input, output at one end.

When using profile input, intermediate output, left and right lever extends to the near close to electric vehicle longitudinal symmetry plane with rack and solid. Because the length of the pull rod increased, the rod pendulum angle decreases when the wheel beat up and down to reduce the movement interference of steering system and suspension system. Tie rod and the rack are fixed and connected with bolts, therefore, the two pull rod and the rack at the same time move to the left or right. So there is the long groove of axial direction on the steering gear shell to reduce its strength.

Using output at both ends, because the drag link length was restricted, it was easy to produce movement interference with the oriented institutions of suspension system. The gear and rack steering of profile input and output at one end is used to the mini van. If the gear and rack steering adopts spur gear with straight teeth mesh rack, the operating stability is reduced, the impact is big, work noise increases. In addition, the angle between the axis of the gear and rack axis can only be rectangular. Adopting helical cylindrical gear and rack of meshing bevel, the contact ratio of gear rack type steering increases, operation is smooth, the noise of shock and work decreased, and the angle between the axis and the axis of the gear and rack is easy to meet the requirements of the overall design.

In the design, the electric car was a mini car, whose structure is simple. The front suspension is a McPherson suspension. In view of the characteristics of the gear rack steering, the gear rack steering of profile input and intermediate output has been selected.

**Selection of the braking system**

The function of braking system is to make the car in the appropriate deceleration speed until the parking. In the downhill road, the braking system can make the car to maintain the stability of the appropriate speed, and make the car reliably parked in situ or slopes. The braking system has at least vehicle brake and parking brake. The former is used to ensure the first function, and in not long slopes guarantee the second function, while the latter is used to ensure the third function. In addition, some car are equipped with emergency braking and auxiliary braking device. The emergency braking device is braking with mechanical force. In some car used dynamic braking or servo brake, in the event of accumulator unit pressure too low failure, emergency braking device is available to realize the car brake. At the same time, it can also be used to a parking brake under human control. Auxiliary braking device can realize continuously when the car down a long slope to slow down or keep a stable speed, and reduce or remove the load of the crane brake system. Vehicle brake and parking brake are consists of two parts such as brake and brake drive mechanism. There are two forms of car brake, drum brake and disc brake.

Drum brake is automobile brake of the earliest form. Before the disc brake has not appeared, it has been widely used in all kinds of cars. Because of structural problems, performances of heat dissipation and drainage are poor and easy to cause the brake efficiency decline. So in nearly 30 years, in the field of cars drum brake has been gradually withdraw for disc brake.

But because the cost is lower, it is still used in some economic class sedan. It is mainly used for rear wheel braking small load and the parking brake. According to the structure of the friction pair of fixed element, disc brakes are divided into pliers disc and wholesale. Caliper disc brake fixed friction element is brake block in a connected to the axle and not around the axis of rotation axle in the brake caliper. The interface of brake pad and brake disk is very small, in the tray of the central angle generally only 30 ~ 50. So this kind of disc brake is also known as disc brakes. When braking, the entire contact friction surface, action pawesrinciple as the clutch, therefore is also called the clutch brake. Multichip full brakes use more. Multichip full brake can be used as a wheel brake, also can be used as a retarder. In hydraulic power, braking force of disc brake is large and stable. It has good braking performance in all kinds of pavement; its braking efficiency is much higher than drum brakes, and air directly through the brake disc, so the heat dissipation of disc brake is very good. In the design, the golf car was a low-speed electric car, road traffic was good, floating disc brake has been adapted to front and rear wheels.

**Parameters checking**

The total quality of electric cars has been estimated: The quality of the motor was 50 kg; the two lead-acid batteries were 73×2 = 146 kg; two passenger were 2 x 75 = 150 kg; in addition, the quality of electric vehicles were about 900 kg

Estimated the total quality of the electric car:

$m_Q = 50 + 73 \times 2 + 75 \times 2 + 900 = 1246$ kg ; so, $m_Q = 1300kg$

the top speed of the Electric car was known, $u_{a\max} \le 25km/h$

$$u_{a_{\max}} = 0.377 \times \frac{n_{\max} \times r}{i} \tag{2}$$

$u_{a_{\max}} = 0.377 \times \frac{n_{\max} \times r}{i} = 0.377 \times \frac{2000 \times 0.1905}{i} \le 25km/h$ So $i \ge 5.75$. Taking $i$ =5.8

In the formula: $n_{max}$: the Highest speed of motor, r/min; r: The wheel radius, m; i: Reduction ratio of the electric car

The following, it i=5.8 has been verified to whether meet the requirements:

According to the design requirements, electric cars can overcome at least 15% of the slope, namely on the slope Angle8.63º, the car can run normally. According to the formula to determine the size of the reduction ratio:

$$i \ge \frac{G(f\cos\alpha + \sin\alpha)r}{T_{tq\max}\eta_T} \tag{3}$$

By the formula (3): $i \ge \frac{G(f\cos\alpha + \sin\alpha)r}{T_{tq\max}\eta_T} = \frac{1300 \times 9.8 \times (0.99 \times 0.015 + 0.15) \times 0.1905}{150 \times 0.92}$

By the calculation, the resistance what the electric car climbing overcome was following:

$$F = F_f + F_i = m_Q g \sin\alpha + m_Q gf\cos\alpha \tag{4}$$

$F = F_f + F_i = m_Q g \sin\alpha + m_Q gf\cos\alpha = 1300 \times 9.8 \times \sin 8.63 + 1300 \times 9.8 \times 0.015 \times \cos 8.63 = 2099.94N$

In the formula: $F_f$: Rolling resistance, N; $F_i$: Ramp resistance, N;α: Slope angle, º.

To make electric cars run normally, reduction ratio should meet the requirements. The driving force of the electric car has achieved the requirements for:

$$F_t = \frac{T_{tq} i \eta_T}{r} = \frac{150 \times i \times 0.92}{0.1905} \ge 2099.94 \tag{5}$$

When i ≥2.9,

In the formula:$T_{tp}$: Motor torque capacity, N·m;$\eta_T$: Mechanical efficiency; r: The wheel radius, m

The calculation has shown that i accorded with a requirement of 5.8. When i= 5.8, the top speed of the electric car changed, and needed be recalculated: by the formula (2),

$$u_{a_{\max}} = 0.377 \times \frac{n_{\max} \times r}{i}$$

$$= 0.377 \times \frac{2000 \times 0.1905}{5.8} = 24.765 km/h \le 25 km/h$$

Finally, the electric car mileage has been verified:

$$S = u_{a\max} \times t = u_{a\max} \times \frac{U - P}{P}$$

$$= 24.765 \times 48 \times 200 \div 2500 = 6510 km \ge 60 km$$

Namely the electric car mileage also met the requirement. Through the above verification, the parameters have met the requirements.

## CONCLUSIONS

Under the premise of in the world advocate environmental protection, under the national macro-control, and in the rapid development of private economy today, in the near future, gas-powered car gradually replaced by a electric cars. And the research and development of electric vehicles need absorb the essence of the structure design of gasoline cars. For the golf stadium, the research and development of special vehicles was not exceptional also to make it more environmental protection, comfortable, reasonable structure. In this paper, the scheme, structure design, and parameter checking were reasonable, and to meet the needs of the body. the vehicle design can meet the demand of golf stadium environment.

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