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New Look and Optimized Power Recovery System for New Energy Vehicles

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Abstract. There are different approaches to reduce the drag on a car in motion, and at the same time, the resistance of the car is affected by many factors. This paper focuses on reducing the resistance of the car from three aspects, namely the weight, the windward area, and the aerodynamics, so as to improve the acceleration and speed of the car. This paper also introduces specific optimization models and sketches through data comparison and calculation. It is reflected that the improved vehicle structure can better reduce the drag, thus achieving the purpose of increasing the speed.

Keywords: Cars, Body structure, Air resistance, Kinetic energy recovery, Air cavity analysis.

1. Introduction

With the rapid development of science and technology, the automobile, which has long been an indispensable means of transportation in people's lives, is undergoing tremendous transformation and evolution. As a product of the time, the new energy vehicle is still in its infancy. Many problems appear and are waiting to be solved by automotive workers. Based on the current rapid development and iteration of new energy vehicles, the exterior design of most new energy vehicles is conservative. Instead, changes and optimizations are made in the power system. Air resistance and vehicle weight are subjects that cannot be ignored in the field of research on vehicle speed improvement. This paper proposes a new optimization model for this subject through comparative analysis, literature analysis, and qualitative analysis, so as to explore whether the designed appearance can effectively improve the performance and comfort of new energy vehicles. This paper aims to accelerate the popularization and development of new energy vehicles, as well as providing reference for the next stage of development.

2. Background information

2.1. Development and importance of streamlined models

Taking a two-dimensional cylinder as an example, its frictional resistance is mainly determined by the viscous shear stress on the wall in the front half, because the boundary layer in the rear half is in a separated state, and the viscous shear stress on the wall is very small. Also due to the separation, the pressure in the rear half can not return to the same level as the front half, resulting in a larger differential pressure resistance. So the formula for resistance can be derived [1]:

$$F = \frac{1}{2} CpSV^2 \tag{1}$$

In the driving process of the car, c is the drag coefficient; ρ is the air density, which cannot be changed; v is the speed of the vehicle, which belongs to the object of improvement; s is the windward area, so the windward area of the car must be reduced first. Considering the height of people and the necessary parts of the car, the windward area cannot be reduced excessively [2]. In order to meet different needs, common car models include sedans, sports cars, off-road vehicles, trucks, buses, commercial vehicles, etc. Different models are designed with different body shapes and different air resistance. The top speed is different. Trucks, buses, and commercial vehicles still appear square due to their relatively low speed. However, due to the high speed of cars, especially sports cars, in order to reduce the windward area and wind resistance coefficient, streamlined design is adopted.

With the attention paid to aerodynamics and the success of the wind tunnel test, the designers changed the aesthetics of the box-shaped car, such as the angular edges. The previously upright front of the car hood becomes slowly sloped towards the ground and the retracted front and rear fenders are gradually integrated with the body structure [3]. The original exposed headlights and spare tires are hidden inside the body. The defect of the vertical downward windshield shape of the box car reduces the air resistance to a certain extent.

Through modeling calculation and bionic simulation, the maximum pressure received by a racing car with a streamlined appearance is 2329.9Pa, while the maximum surface pressure of a jeep is 2559.5Pa [4]. Therefore, under the same conditions, jeep will experience more air resistance according to the Stokes Equation (2) and the Turbulent Kinetic Energy (3).

$$\frac{\partial \overline{u}_i}{\partial t} + \frac{\partial}{\partial x_j}\left(\overline{u}_i \overline{u}_j\right) = -\frac{\partial \overline{p}}{\partial x_i} - \frac{\partial}{\partial x_j}\tau_{ij} + \frac{1}{Re}\frac{\partial^2 \overline{u}_i}{\partial x_i \partial x_j} \tag{2}$$

$$\frac{\partial k}{\partial t} + U_j \frac{\partial k}{\partial x_j} = P_k + \frac{v_t}{\sigma_k}\frac{\partial k}{\partial x_j} - \varepsilon \tag{3}$$

Surface pressure, air swirl, and shear force are the three factors that produce drag when the vehicle is moving. First, from the simulation analysis results, during normal operation (60km/h), the front surface pressure of the car is greater than that of the jeep; the second is that there are more air vortices around the jeep. The higher the speed of the vehicle, the greater the effect of the air vortex on the stability of the vehicle. During the normal operation of the vehicle, since the speed of the vehicle is large enough, the influence of this factor is very obvious; thirdly, during the normal operation, the difference between the shear force of the racing car and the jeep is not large, and this factor is only obvious at a low speed. As a result, a car with a streamlined appearance is less affected by air interference (drag, vortex, etc.) when running. Under the same driving force, the streamlined appearance of the racing car reduces the power loss of the engine, thereby reducing the fuel consumption and increasing the maximum speed and acceleration compared with the Jeep.

2.2. Material optimization on the auto parts and battery pack

In electric vehicles, battery life is also a critical consideration [5]. In addition to tire parameters, motor performance, reducer reduction ratio, and wind resistance will affect the battery life of new energy vehicles. The weight of the vehicle will also have a huge impact [6]. Lightweight materials are currently dominated by high-strength steel, aluminum and magnesium alloys, and composite materials. In auto parts, the use of aluminum alloys has increased from 4% in the 1980s to 29% in 2010 [7]. Compared with the study of complex materials with technical limitations, the optimization of battery pack structure can solve the problem of too large battery pack mass more easily [8]. The China's Segway-Ninebot launched an electric bicycle this year that can turn an induction motor into a generator when the accelerator is released, re-converting kinetic energy into electrical energy and storing it in a battery. This technology still has a lot of room for improvement in theory, and it also

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provides important guidance for the field of electricity recovery. In general, when more suitable materials are used to make the battery pack, the weight of the battery can be greatly reduced. Coupled with the improved power recovery system, the battery is more durable, greatly extending the service life of the battery pack, reducing the number of batteries, so as to achieve the purpose of increasing the speed of the car.

3. An optimization plan proposed for new energy vehicles

However, because of the extremely complex body structure and engine system of traditional fuel vehicles, a certain volume is required to contain all the accessories, which has limitations in achieving the streamlined appearance. Through analyses and sketches, this paper proposes a more streamlined appearance and an optimized power recovery system by reducing the weight of the whole vehicle according to the drag reduction factors of new energy vehicles, to reduce the number of battery packs and obtain measures to increase the speed of new energy vehicles.

3.1. Introduction of the air duct

In the early 20th century, the first "carriage-shaped" sedan evolved into the "box model". This model simply installed doors, windows, and a roof on the frame, and its safety and comfort were seriously insufficient; The evolution of the "streamlined" Beetle is a historic experiment. In 1945, the Ford Motor Company introduced the theory of ergonomics to the overall design of the car. The body shape of this car is quite like a boat, so people call it a "boat-shaped car". By 1952, the Buick sedan of General Motors of the United States created the era of "fish-shaped car". After a lot of exploration and experimentation, the designers found a new type of car - the wedge. Nowadays, the research and development of car styling by major auto companies are still continuing, and people's travel experience is becoming more and more exciting.

The development trend of automobile aerodynamics can be roughly summarized into the following directions: first, it is the perfect combination of the aerodynamic model and aesthetic model of the car; second, it emphasizes the smoothness of the entire body surface; third, the development of the overall aerodynamic model should pay attention to the low resistance body and the low body height; fourth, the aerodynamic additional devices and the overall shape coordinate and integrate with each other; fifth, the car body surface has no adhesion; sixth, the car rear exhaust grille and engine exhaust are fully utilized at the same time to improve the occurrence of rear wake conditions; seventh, the optimal curved shell shape line is based on the wedge-shaped car shape. Generally speaking, car detours can be divided into two simple types: the first type is the detours on the outside of the car, that is, all the airflow around the surface of the car; the other type is the car's fleshy detours. The increase of the speed is restricted and influenced by many factors. For example, air density, windward area, the mass and appearance structure of the car. Considering the fluid mechanics and the weight of the car itself, the resistance of the car and the excessive weight of the battery of the new energy vehicle are the main factors restricting the speed of the car. At present, domestic and foreign car manufacturers and car workers are concerned about the air resistance reduction when the car is running, and have carried out a lot of related experiments. Experimental research shows that when the speed of the car is close to 100 kilometers per hour, the restriction of air resistance on the speed of the car is more obvious. At this time, nearly 80% of the power of the engine is used to overcome the influence of air resistance. In this regard, this paper proposes a type of new car appearance (as shown in Figure 1 and 2), and the sketch below is the general appearance of the design. It can be more in line with the way of reducing air resistance by using the appearance of a streamlined car. By proposing the concept of “air duct", the weight of the car itself can be greatly reduced. The air duct can use the relationship between the fluid flow rate and the force to provide greater downforce, allowing the car to get closer to the ground when driving fast to prevent slipping. Smaller weight and reduced wind resistance can also further improve the battery life of new energy vehicles.

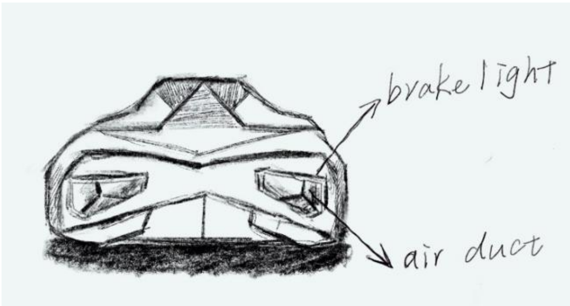

Figure1. The rear view.

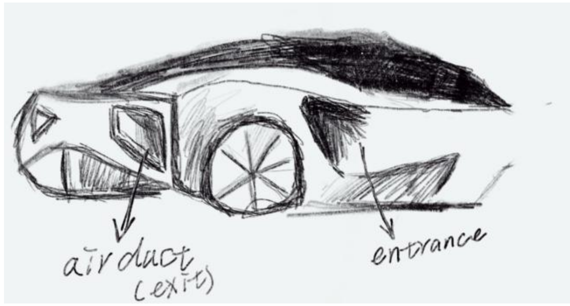

Figure 2. The side view.

3.2. Improvements to the power recovery system

As for the power recovery system, the new appearance allows the wind to pass through the new structure when the car is driving fast, cooling the body due to friction and the internal energy generated by the motor braking. This greatly improves the work of the limited battery of the new energy vehicle. Therefore, it can achieve the purpose of reducing the number of batteries, reducing the weight of the whole vehicle, and improving work efficiency. In the process of normal driving of the car, the pointer of the ammeter is always in a static state at the position of the maximum value, which means that there is a problem of excess power in the car generator. When starting the car at night, if the car generator keeps running at a high speed and all lights are always on, it will not only damage the car generator circuit, but also cause excessive consumption of battery electrolyte, thereby shortening the service life of the battery. In order to ensure the safe and stable power cycle of the car under the condition of reducing the number of batteries, the author intends to add a monitor to the improved power recovery system, which can detect the actual situation of the contacts and joints of the magnetic induction generator in real time, thus checking whether there are common problems such as a poor contact and short circuit [9].

3.3. Application of various materials in lightweight automobile structure

3.3.1. High strength steel. High-strength steel can maintain a stable shape after being subjected to huge pressure. Compared with ordinary metal materials, it can provide greater support under the same quality. However, due to its non-corrosion-resistant characteristics, it can only be used for making the car shell.

3.3.2. Magnesium alloy. Magnesium alloys have less density. Because it has the characteristics of low density and high strength at the same time, it will be easier to be processed, and it is usually used for coating in the design of automobiles to improve the overall strength of the automobile appearance.

3.3.3. Titanium alloy. The rare metal titanium has a melting point of 1700 degrees Celsius and is a very heat-resistant metal material. Therefore, the inner part of the "wind tunnel" can be made of titanium alloy. Titanium alloy also has very light weight and high enough strength to withstand severe reactions for a long time without deformation or fracture. It can reduce the weight of the new energy vehicle and improve the stability of the part of the structure.

4. Conclusion

By controlling variables and constructing rational model simulation experiments, the important position of streamlined appearance in the future appearance design of new energy vehicles is determined. By improving the battery pack of new energy vehicles and optimizing the power recovery system, the car can reduce its own weight in two different dimensions, so as to achieve the purpose of increasing the acceleration and top speed of the car. By increasing the design of the “air duct”,

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reducing the number of batteries, and improving the materials of the whole vehicle, the weight of the new energy vehicle with the new appearance can be reduced by about 15%. Compared with the current fuel sports car, the new exterior design can reduce the air resistance by about 8%. Monitors in the new power recovery system and the large amount of downforce generated by the "air duct" allow the car to be in safer and more stable driving conditions at high speeds. By integrating multiple components with simpler materials, structures and processing techniques can effectively reduce the quality and cost of automobiles. This way of integrating components to reduce structural mass has a wide range of application in automotive plastics and castings. The integrated parts processed by the emerging tailor-welded blank forming technology have effectively improved the strength, saved the space, and resisted certain corrosion [10]. At present, due to the production limitations of materials and batteries and the substantial increase in cost, it is difficult to mass-produce the new appearance of new energy vehicles. The analysis and design sketches in this paper remain in qualitative research, and the specific data and correlation coefficients can only be determined after a large number of experimental tests. However, increasing the speed of new energy vehicles and the new power recovery system through the design concept of "air duct" has important guiding significance for the safety and practical development of new energy vehicles in the future.

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