Analysis and Optimization of Rear Wheel Core of FSC Racing Car Based on ANSYS

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Abstract. In order to ensure the stability of the car, ANSYS software is used by Start Point racing team of Beijing institute of technology Zhuhai to analyze the car driving wheel core, the results show that the core of the rear wheel made of pure aluminum alloy material conform to the requirements of the car to the deformation, also meet the requirements of the material properties of stress, but cannot meet the requirements of the wear and tear, so adding interference fit bushing, can improve its wear resistance.

1. Introduction
The wheel core is the central part of the racing system, and the rear wheel core as the driving wheel is complicated and has great influence on the vehicle performance and stability. The wheel core is designed to be as lightweight as possible while meeting the stability requirements of the car. Therefore, it is necessary to find a balance between stability and lightweight through analysis, so as to get a more ideal design scheme[1]. The second generation racing car of Beijing Institute of Technology Zhuhai chooses 7075 aluminum alloy as the material of wheel core, and adopts the design scheme of coupling integral wheel core. The characteristics of this design are: one end of it is directly connected with the rim, the other end is connected with the three ball pins on the half shaft, so as to be affected by the driving torque; The brake disc is designed to be installed so that the wheel core is subjected to torque caused by braking force when braking. This paper mainly analyzes these two situations, and analyzes whether the rear wheel core meets the requirements in structure and wear according to the results, and obtains the optimization scheme.

2. Determination of wheel core parameters
The racing car of Beijing Institute of Technology Zhuhai uses OZ rim with a diameter of 13 inches and 205/470 R13 horse tire. Considering the layout of parts in space, it adopts three-ball pin universal joint, brake disc is floating brake disc, and wheel core is used to install the wheel and brake disc parts. The rear wheel core also needs to transmit the torque output by the engine to the wheel through the half shaft, so the rear wheel core also integrates the structure of the ball cage[2]. There are two flanges on the wheel core, one for the hub and one for the brake disc. The wheel core and tire rotation with high-speed rotating parts, is part of the suspension spring under the quality, wheel core is made of aluminum alloy and to
satisfy the intensity and rigidity under the premise of lightweight design. The 3d model of the designed wheel core is shown in Figure 1.

![Figure 1. 3D model of rear wheel core](image)

### 3. Stress analysis of rear wheel core based on ANSYS

In many parts of the transmission system, the force on the wheel core is more complex, especially the rear wheel core. The wheel core is made of 7075 aluminum alloy. Check 7075 aluminum alloy in ANSYS Engineering Data, and then import the 3D solid modeling of the wheel core. Mechanical mesh is used for automatic division, and Sizing is used to locally refine the mesh of key parts. The average quality coefficient of the generated mesh is 0.81, indicating that the mesh quality is good[3]. The load received by the rear wheel core includes the output load of the half shaft, the gravity load of the racing car and the brake load of the brake disc. The rear wheel core mainly receives large torque in braking and ejection conditions, so the analysis is carried out under these two conditions.

#### 3.1. Braking condition

In braking condition, the rear wheel brake disc brake load and gravity load of the car, the set of methods of the boundary conditions is the rear wheel core fixed constraints imposed at the hub bolt installation, and then match the wheel core and the pillar of applying gravity load bearing installation location, places a torque on the brake disc flange load (figure), Thus, the stress of the rear wheel core in emergency braking is simulated, as shown in figure 2-5.

![Figure 2. Brake loads are applied to the wheel core.](image)

![Figure 3. Mesh division of wheel core](image)

![Figure 4. Stress distribution of wheel core.](image)

![Figure 5. Distribution of wheel core variables](image)
The results show that the maximum stress of the wheel core is 38.95MPa and the minimum safety factor is 12.15, which meet the design requirements.

3.2. Working condition of ejector

Under the ejection condition, the rear wheel core is subjected to the torque load of the half shaft and the gravity load of the racing car, the setting method of boundary conditions is to impose fixed constraints on the hub bolt installation position of the rear wheel core and rotary support constraints on the bearing installation position of the wheel core matching the suspension column. The torque is converted into pressure in the inner wall of the wheel core ball cage, and the torque value is the output torque of the half shaft, so as to simulate the force of the wheel core in the process of the car ejection start, as shown in figure 6-9.

![Figure 6. Ejection loads are applied to the wheel core.](image1)
![Figure 7. Wheel core variable distribution](image2)

![Figure 8. Distribution of safety factor of wheel core.](image3)
![Figure 9. Stress distribution of wheel core](image4)

The results show that the maximum stress of the wheel core is 265.51MPa and the minimum safety factor is 1.9, which meet the design requirements.

4. Analysis

4.1. Structure requirements

The tensile strength and yield strength of 7075 aluminum alloy are 524MPa and 462MPa respectively[4]. It can be seen from the above analysis results that the stress of the parts in both cases meets the requirements. The parts are processed by ordinary lathe, machining center, CNC milling machine and other machine tools. The allowable error is ±0.05mm during processing. The above analysis results show that the deformation of the parts is less than 0.03mm in both cases, so the deformation is within the allowable range and can meet the normal driving requirements of the racing car.
4.2. Wear requirements

The hardness of 7075 aluminum alloy is 150HB. The wear of the wheel core under the maximum stress was analyzed at the contact point between the three ball pins and the wheel core under the torque. Wear form is abrasive wear, wear quantity is:

\[ W_V = K_a \frac{N}{H} \]  

Therefore, \( \frac{W}{s} = K_a \frac{N}{s H} \), That is: \( h = k_a \frac{P}{H} \).

\( H \) is the wear depth per unit area, \( K_a \) is the wear coefficient, \( P \) is stress, \( H \) is hardness.

The wear depth per unit area is 0.11mm and the machining error is ±0.05mm. Considering the mileage the car needs to travel, this wear is too much to meet the requirements.

5. Optimization scheme and analysis

Considering the need for wear, a Cr12Mov steel bushing is installed at the position where the wheel core contacts with the three ball pins, as shown in figure 10. The bushing adopts wire cutting and silk finishing.

![Figure 10. A steel bushing made of Cr12Mov.](image)

The wear of the wheel core under the maximum stress was analyzed at the contact point between the three ball pins and the wheel core under the torque. The hardness of Cr12Mov steel bushing after quenching and tempering treatment is 60HRC, and the wear depth of unit area is 0.03mm, while the machining error is ±0.05mm[5]. The wear depth meets the requirements, and the wear depth of this design is reduced by 72.7% than the original design, so this optimized design is adopted.

6. Conclusions

ANSYS software is used to analyze the above two schemes in terms of structure, force and wear, and the following conclusions are drawn:

1) The main purpose of FSC racing parts design is to improve the performance of the vehicle as lightweight as possible under the condition of meeting the requirements. Aluminum alloy can be used as the material to manufacture parts to meet the requirements of the structure, but the wear will be large in the place where the force is large.

2) The optimization scheme of adding bushings to the rear wheel core increases the quality, but this scheme meets the requirements of wear of parts on the premise of meeting the structural requirements, thus balancing the lightness and stability and improving the stability of the whole vehicle.

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