College Students' Formula Racing Brake System Design

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Abstract

Formula SAE car's design must be in acceleration, braking and handling performance. Among them, in order to guarantee the safety of the vehicle and driver, braking system design is especially important. Based on the analysis of the competition rules and past molding car, on the basis of analysis by calculation braking system overall scheme are given. Among them, the braking system to brake as the core, designed the brake operating mechanism and brake control driving mechanism. Refer to physical objects and the classic case in design process, the parts to make use of Solidworks three-dimensional modeling and assembly, optimize the braking control drive mechanism, using CAD, CAXA, such as motion interference analysis, to ensure the rationality of the design and the optimal benign.

Keywords

Car, brake system, simulation, finite element analysis.

1. The Importance of the Brake System

As a modern and important means of transport on land, cars have many large components that guarantee their performance, the so-called "assembly", and the brake system is one of the important assemblies. It can both slow down the car in motion and ensure that the car parked after parking is not in place. It can be seen that the car brake system plays an important role in ensuring the safety of the car and the reliability of the parking. Nowadays, with the continuous expansion of the highway network, the increase of the vehicle speed and the increase of the traffic density, the operational reliability requirements of the vehicle brake system are becoming increasingly important. Because only the car with good braking performance and reliable braking system can fully exert its high-speed driving performance and ensure the safety of driving. It can be seen that the brake system is a very important part of the car, so it is very important to analyze the structure and design of the brake system of the car.

2. Brake System Design

2.1 Brake System Should Meet the Main Requirements

Main requirements should be met when designing the braking system: 1. Sufficient braking efficiency; 2. 2. Reliable work; 3. When braking at any speed, the vehicle should not lose control and directional stability; 4. Prevent water and sludge from entering the working surface of brake; 5. Good thermal stability of braking capacity; 6. Easy to operate and good follow-up; 7. When braking, the noise produced by the braking system should be as small as possible, and at the same time, efforts should be made to reduce the emission of materials such as asbestos fiber which is harmful to human body, so as to reduce public hazards. 8. The hysteresis should be as short as possible; 9. Friction liner shall have sufficient service life; 10. After the friction pair is worn, there should be a mechanism that can eliminate the clearance caused by wear, and it is easy to adjust the clearance. It is best to set an

automatic clearance mechanism. 11. When any component of the brake drive device fails and its basic function is damaged, the car brake system shall have sound or light signals and other alarm prompts.

2.2 Structure Type and Selection of Brake

There are friction brake, hydraulic brake and electromagnetic brake. Although electromagnetic brake has the advantages of good hysteresis, easy connection and reliable joint, it is only used as wheel brake or speed retarder in some commercial vehicles with large total quality due to high cost. Hydraulic brakes are generally used only as a retarder. Friction brakes are still widely used.

Friction brake is to use the friction between the fixed element and the working surface of the rotating element to produce braking torque to slow down or stop the car. It can be divided into drum type, disc type and belt type according to different forms of friction pair structure. A belt brake is used only as a central brake. There are many types of drum and disc brakes.

In this design, we choose sliding floating clamp disc brake, which has the following advantages: 1. Good thermal stability; 2. 2. Good water stability; 3. It is easy to form a double-circuit braking system, so that the system has high reliability and safety; 4. Small size, small quality and good heat dissipation; 5. The pressure is evenly distributed on the brake liner, so the wear of the liner is also uniform. 6. Easy to replace the liner; 7. The clearance between the liner and the brake disc is small (0.05~0.15mm), which shortens the braking coordination time. 8. Easy to realize automatic clearance adjustment.

2.3 Main Parameters of Braking System and Its Selection

The braking system parameters that have important influence on the braking performance of automobile include: braking force and its distribution coefficient, synchronous adhesion coefficient and brake factor.

2.3.1 Braking Force and Braking Force Distribution Coefficient

When a car is braking, if the rolling resistance moment of the road surface to the wheel and the inertial moment of the automobile rotating mass are ignored, then the torque balance equation of any wheel with angular velocity $\omega > 0$ and the vehicle torque is:

$$T_f - F_B r_e = 0 \tag{1}$$

Where, T_f -- the braking moment of the brake on the wheel, namely the frictional moment of the brake, whose direction is opposite to the rotation direction of the wheel, N/m.

F_B --The braking force that the ground ACTS on the wheel, namely the friction between the ground and the tire, also known as the ground braking force, is opposite to the direction of the car, N.

r_e -- the effective radius of the wheel, m.

r_e -- the effective radius of the wheel, m.

$$F_f = \frac{T_f}{r_e} \tag{2}$$

It is also called brake force, which is the force needed to overcome brake friction torque at the wheel rim.

The synchronous adhesion coefficient of a vehicle at full load φ_0=1.

Under synchronous adhesion coefficient, braking force of front and rear wheels simultaneously locked:

$$F_{f1} = \frac{G}{L}\left(L_2 + \varphi h_g\right) = \frac{3020}{1680}\left(840 + 300\right) = 2076.25 \tag{3}$$

$$F_{f2} = \frac{G}{L}\left(L_1 - \varphi h_g\right) = \frac{3020}{1680}\left(840 - 300\right) = 943.75 \quad (4)$$

Brake power distribution coefficient β :

$$\beta = \frac{F_{f1}}{F_f} = \frac{2076.25}{3020} = 0.6875 \quad (5)$$

2.3.2 Brake Factor

$$BF = \frac{T_f}{PR} \quad (6)$$

Where, T_f -- friction moment of brake;

R -- the total radius of the brake disc;

P -- input force. Generally, the average value of the compressive force added to the two brake blocks is taken as the input force.

3. Structural Design of Main Brake Parts

3.1 Brake Disc

The machining precision of the working surface of the brake disc should meet the following requirements: the flatness tolerance R_a is 0.012mm, the surface roughness value is 0.7-1.3m, the parallelism tolerance of the two friction surfaces should not be greater than 0.05mm, and the end face circular run-out tolerance of the brake disc should not be greater than 0.03mm. Usually the brake disc is made of pearlitic gray iron with good friction performance. To ensure sufficient strength and wear resistance, the brand name should not be lower than HT250. This design USES motorcycle brake disc, the reference material chooses 40Cr.

3.1.1 Diameter of Brake Disc

In this design, the selected rim diameter is 13 inches. According to the automobile design manual, the brake disc diameter is usually 70% ~ 79% of the selected rim diameter, i.e. 231.14mm~260.858mm.

3.1.2 Brake Disc Thickness

It has an influence on the quality and working temperature of brake disc. In order to make the quality smaller, the thickness of brake disc should not be too large. In order to reduce the temperature rise, the brake disc thickness should not be too small, this design chooses mm.

3.2 The Brake Caliper

Brake calipers are made of wrought grey cast iron kth370-12 or ductile iron qt400-18, also made of light alloy, which can be made as a whole (FIG. 4-1) or in two halves and bolted together. The outer edge has an opening so that the brake block can be inspected or replaced without removing the brake pliers. Brake calipers shall have high strength and stiffness. Brake cylinder is usually processed in the clamp body, and the separately made cylinder is also installed into the clamp body. In order to reduce the heat transferred to the brake fluid, the open end of the cup piston is usually topped by the back plate of the brake block (FIG. 4-1 and FIG. 4-2). The open end of some pistons is cut into a staircase, forming two small semicircular circular end faces opposite each other in the same plane. Pistons are made of cast aluminum or steel. In order to improve wear resistance, the piston's working surface is chrome plated with Venus. When the brake clamp body is made of aluminum alloy, it is necessary to reduce the heat transfer to the brake fluid. Therefore, the contact area between piston and brake block back plate should be reduced.

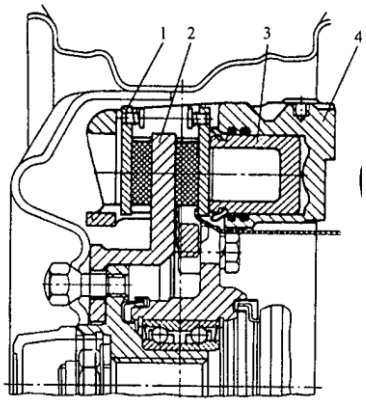

Fig. 1 General structure of floating clamp disc brake

3.3 Brake Cylinder

Brake wheel cylinder is a piston brake shoe opening mechanism used in hydraulic brake system. The cylinder body of the cylinder is made of gray iron HT250. Its cylinder bore is through hole, need boring and grinding. The piston is made of aluminium alloy. The majority engine cylinder has two equal diameter pistons.

4. Conclusion

In this design, we choose sliding floating pliers disc brake, the braking system power distribution coefficient β=0.6875, the braking system adopts floating clamps disc brake, the front and rear wheel brake design is consistent. The brake disc is made of 40Cr die-casting, and the braking circuit adopts hydraulic type II pipeline layout. The main brake pump is mitsubishi pajero brake main pump.Acknowledgements.

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