Disc Brake Equal Analysis of Car

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Abstract - This paper carries on automotive force when car is braking, braking force is established. The distribution of braking force is analyzed. This paper presents a method to analysis on brake equeal. A new finite element model of brake system based on surface contact was established. After contrast of the results, the main reason of the brake noise in the braking process is found**.**

Index Terms - brake equal, force, noise

1. Introduction

Brakes are one of the most important safety and performance components in automobiles[1]. Appropriately, ever since the advent of the automobile, development of brakes has focused on increasing braking power and reliability. However, the refinement of vehicle acoustics and comfort through improvement in other aspects of vehicle design has dramatically increased the relative contribution of brake noise to these aesthetic and environmental concerns. Brake noise is an irritant to consumers who may believe that it is symptomatic of a defective brake and file a warranty claim, even though the brake is functioning exactly as designed in all other aspects. Thus, noise generation and suppression have become prominent considerations in brake part design and manufacture.

A number of theories have been formulated to explain the mechanisms of brake squeal at present. Cao present a numerical method to calculate the unstable frequencies of a car disc brake[2]. In order to accurately calculate vibration frequency of disk brake, the friction induced nonlinear vibration of disk brake is studied by using the multi body dynamics analysis method[3]. Su and Guan aiming at the target of substructure modification for reducing brake squeal, the modification method in optimal design is investigated[4]. However, none of these models have attempted to include the effects at all scales mentioned above[5].

2. Model Disc Braking

Structure of disc brake system is shown in figure 1. There is different disc brake friction in disc area, divided into full type and the caliper disc. And the structure of the caliper disc is shown in figure 1. Low frequency brake squeal noise is due to the coupling between the bending modes of vibration of the disc and the pad When the two congnnents, disc and pad. start to vibrate together, the system damping for that specific system resonance 15 reduced, since the Joint damping between pad and disc decreases. As a consequence, the friction forces may introduce more energy into the system than it can dissipate. Fig 1 shows a typical floating-caliper disc brake system with insulators.

Brake disc of the two pistons at both sides of the brake disc 1, 2 brake 5 fixed clamp body is installed on the axle 6 and across it on the brake disc 1, it can't rotate or move along the axis of the brake disc, brake, brake oil by the master cylinder by the oil inlet 4 into two common hydraulic pliers body cavity, the three pressure of brake block and the wheels on both sides of the fixed connection of the brake disc 1, resulting in a brake. Disc brake of the thermal stability of the drum brake with water, and braking equipment easier, better braking has high stability, disc brake were widely used and in the brake of the car.

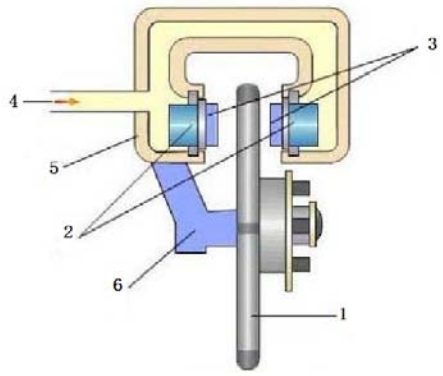

Fig 1 Automobile brake system structure

The disc brake is shown in figure 2, because the disc brake has the more virtues than the drum brake, the disc brake is widely applied in the real life.

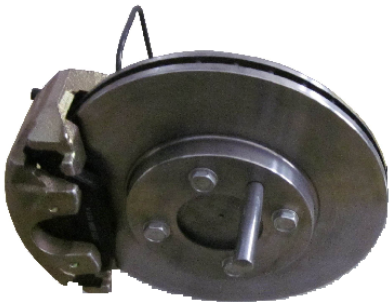

Fig 2 Structure of braking disc

3. Braking Force of Disk Braking System

A simplified diagram of the force on braking disc is shown in Figure 3, when brake of the car is subjected to force F, the car is in equilibrium state.

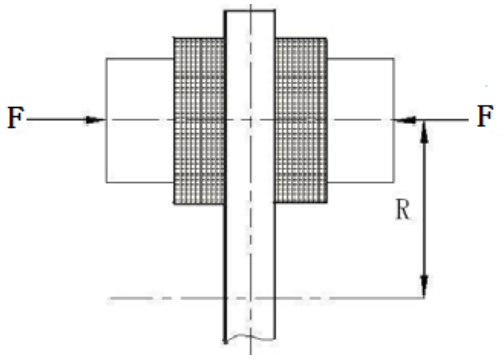

Fig3 Force on braking disc

Assuming the contact is good when the car is braking, and the pressure distribution is uniform throughout, brake torque is:

$$T_f = 2\rho_v FR \qquad (9)$$

$$R_m = \frac{R'+r}{2}$$

Where ρ_v is the equivalent coefficient of friction between the brake pad and the brake disc,F is the pressing force of the brake disc, R is radius, R_m is average radius. The outer and inner radius respectively is R' and r' .The average radius is:

$$R_m = (R'+r)/2$$

The radius of braking disc is shown in the Fig4.In order to analysis the force during the braking, small area is analyzed.

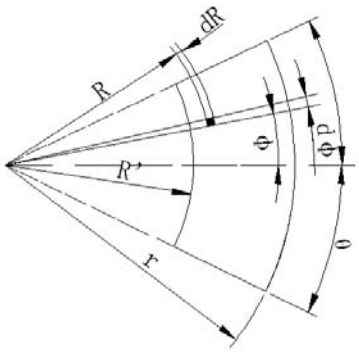

Fig 4 radius of braking disc

RdRdφ is small area, qf1RdRdφ is the friction force on braking disk, qf1R2dRdφ is the friction torque of the center , q is pressure on unit area between the pad and the brake disc. RdRdφ is small area which is acted by total friction force between unilateral block and brake disc,the friction on the braking disc is:

$$F_f = F_y \rho_v RdRd\phi \qquad (10)$$

Where F_y is pressure force between braking block and braking disc. The friction moment on the braking disc is:

$$T_f = F_y \rho_v R^2 dRd\phi$$

The total friction on the braking disc is:

$$F = \int_{-\theta}^{\theta}\int_{R}^{r} F_y \rho_v RdRd\phi = F_y \rho_v \left(r^2 - R'^2\right)\theta$$

The braking force on the braking disc is:

$$T = \int_{-\theta}^{\theta}\int_{R}^{r} F_y \rho_v R^2 dRd\phi = \frac{2}{3} F_y \rho_v \left(r^3 - R'^3\right)\theta$$

The total friction force and the total braking torque are gotten by the above calculation in the process of braking. When the car is braking ,the angel acceleration ε (t) is:

$$\varepsilon(t) = \frac{M_0}{J}\left(1 - e^{-\eta\frac{t}{t_0}}\right) \qquad (11)$$

Where ε is acceleration of braking disc，J is moment of inertia of braking disc,： To the above formula for time points, and the initial angular velocity ω_0 of the brake disc, get the brake plate of angular velocity within the time required is

$$\varepsilon(t) = \omega_0 - \frac{M_0}{J}\left(t + \frac{t_s}{\eta}e^{-\eta\frac{t}{t_0}} - \frac{t_s}{\eta}\right) \qquad (12)$$

Through the above formula to calculate the angular acceleration of car when braking.

4. Noise and Vibration

Vibration generated during braking is the causes of noise, vibration amplitude in vibration velocity noise intensity level is determined. Experiments show that, this relationship between vibration velocity and sound pressure is

$$L_p = Lv = 101g\left(\frac{v_p}{v_0}\right) = 101g\left(\frac{P}{P_0}\right)^2 \qquad (13)$$

Where Lp, Lv is sound pressure level of noise and vibration velocity stage; V0 is the normal reference velocity; P is sound pressure; P0 is reference sound pressure. The formula of coordinate transform is:

$$x = A\sin(\omega t + \varphi) \qquad (14)$$

The speed is :

$$v = \dot{x} = A\omega\cos(\omega t + \varphi)$$

With the help of the modal mechanical parts of the

analysis, the first analysis of each component amplitude brake prone to brake squeal frequency, then the structure design to suppress the brake squeal objective.

5. Finite Elementand Simulation

5.1 Size and Material

In the software, three-dimensional model is shown in Fig 5, the friction factor between the wheel set 0.2.

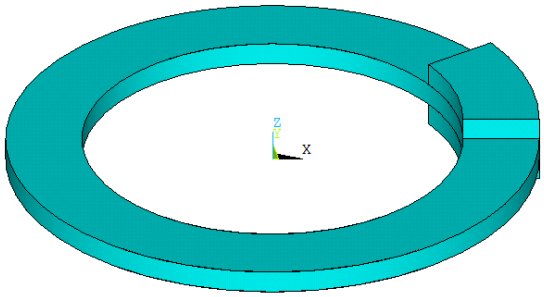

Fig 5 disc braking and parameters of Frictional Material

The thickness of turning disc is H_1=0.015,the thickness of disc braking is H_2=0.015, the inner radius of turning disc is r=0.125,external radius of turning disc is R'=0.175, wrapping angle of disc braking is 350, friction coefficient between braking block and disc braking is 0.2. The materials of brake disc and the friction plate is shown in table 1.

Table1 Materials and properties of braking

braking	brake disc	friction plate
elastic modulus	200	28
poisson ratio	0.3	0.3
material density	7800	6000
material	gray iron	semimetal

5.2 element type and meshing

Select the SOLID186 simulation disc and brake plates, sliding contact and contact unit 174 and target 170 simulator and the brake pads, carries on the grid division in the software, such as mesh model is shown in figure 6

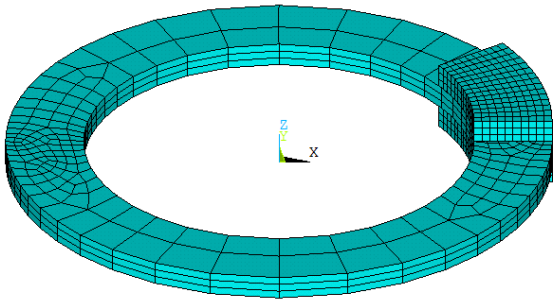

Fig 6 meshing

The constraint is established in the software, in order to constraint the disc, constraint between above and under disc is established in the X,Y direction, Constraint model is gotten in the fig7.

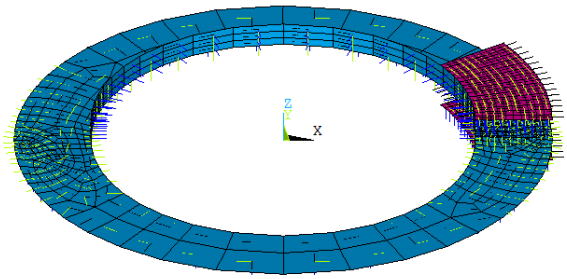

Fig 7 Constraint model

The constraint stress above two sides add corresponding is added in order to analyse braking.

5.3 Modal and result

The figure 9-12 show different order in the process of brake mode vibration of the figure, when the car is braking at the start of the friction between the brake disc, incentive is small.

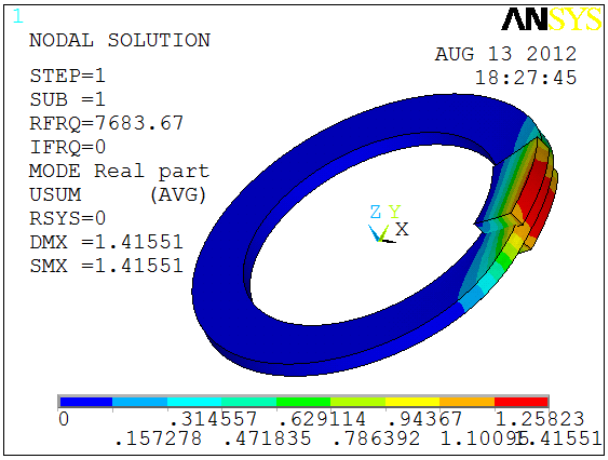

Fig 8 1 order vibration model

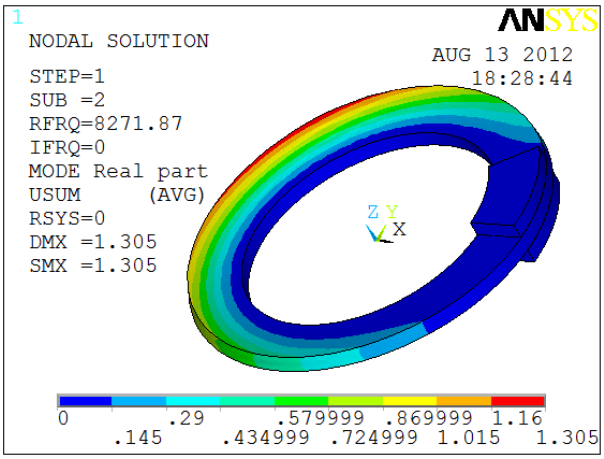

Fig 9 2 order vibration model

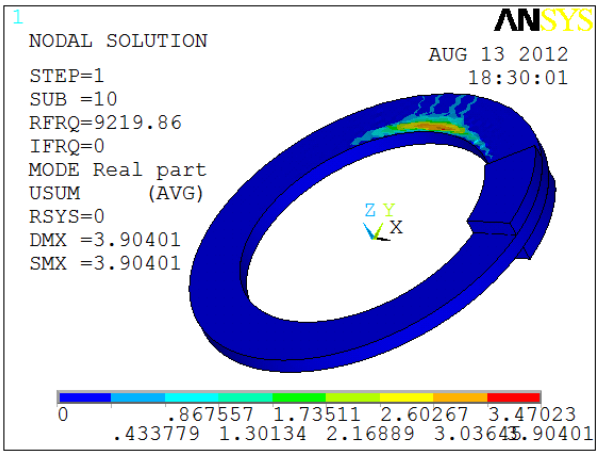

Fig 10 11order vibration model

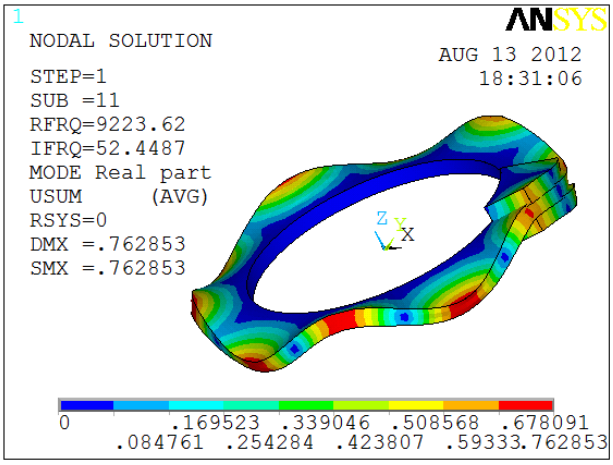

Fig 11 12 order vibration model

As can be seen from the graph, the first several order model is stable without the brake screaming, from the 11 order vibration model of brake can be seen, there has been no stable state in the middle part of the model, so there will be screaming, as the order increases, the brake squeal will become more and more obvious.

6. Conclusions

This paper established the model of the automobile braking process of force, and carried on the theoretical analysis, given the constraint mode during braking brake disc and the force on friction plate is calculated and analyzed, modal and the actual situation is very close. Through the analysis of real modal components can understand their vibration characteristics is crucial for good, to reduce the braking process of screaming through improving the structure design function.

Acknowledgment

The financial support of Hebei province department of project (12217630) and department of education of Hebei Province (ZH2012071) are gratefully acknowledged.

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