Finite Element Analysis of Steel Plate Spring Suspension for Medium Truck

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Abstract

Suspension is a general term for devices that ensure elastic connection between wheels or axles and vehicle carrying systems, and can transmit loads, mitigate shocks, attenuate vibrations, and adjust the position of the vehicle during driving. The main function of the suspension is to transfer all the forces and moments between the wheel and the frame, and to ease the impact of the vehicle running over the uneven pavement, and attenuate the vibration of the bearing system to ensure the ride comfort of the car. In this paper, the structural form of suspension is briefly introduced, and various factors affecting suspension motion are analyzed. The finite element software HyperWorks is used to analyze the front leaf spring suspension. It provides more valuable information for further design of leaf spring suspension.

Keywords

Suspension, Leaf spring, Finite element analysis.

1. Introduction

Suspension is one of the most important assemblies in a car. It connects the frame to the wheel elastically. Its main task is to transmit all the forces and moments between the wheel and the frame. The impact load transferred from the road surface to the frame can be alleviated, the vibration of the whole load caused thereby can be weakened, and the smoothness of the vehicle can be ensured. It ensures that the wheels have ideal motion characteristics when the road surface is uneven and the load changes, and ensures the stability of the vehicle operation, so that the vehicle can get high-speed driving ability[1].

Although the automobile suspension has been evolving from the structure form to the principle of action for the past more than 100 years, it is composed of three parts of the elastic element, the vibration damping device and the guiding mechanism from the structure function. In some cases, a component may act in two or three ways, such as a steel spring acting as a flexible element and a guide mechanism.

The guiding device consists of a guide connecting rod to determine the motion characteristics of the wheel relative to the frame, and transmit various forces and moments other than the vertical force of the elastic element special delivery. When the longitudinal leaf spring is used as an elastic element, it can also act as a guiding device. The buffer block is used to reduce the direct collision between the wheel and the frame and prevent excessive deformation of the elastic element. A car equipped with a lateral stabilizer can reduce the lateral tilt Angle and lateral Angle vibration of the frame when turning.

2. Structure form and Analysis of Suspension

In order to meet the needs of different models and different types of vehicle Bridges, suspension has different structural forms.

2.1 Non-independent Suspension

Non-independent suspension is the structure of wheels suspended relative to individual wheel suspension. The structure of the non-independent suspension is characterized by two wheels connected by an integral frame, and the wheels and Bridges are suspended under the body by elastic suspension. The non-independent suspension has the advantages of simple structure, high strength, low cost and small change of front wheel positioning in traffic. However, due to its poor comfort and handling stability, it is basically no longer used in modern cars and is used in trucks and buses.

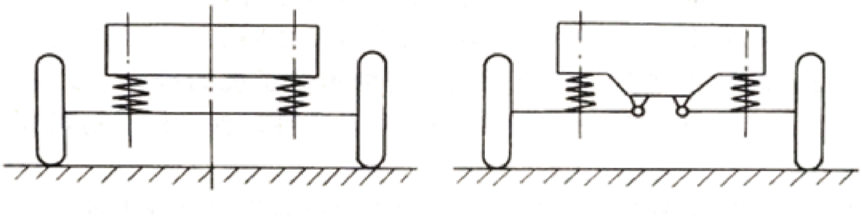
The two sides of the independent suspension are mounted on an integral axle, and the vehicle bridge is connected with the frame through suspension. The suspension structure is simple and the transmission force is reliable, but the two wheels will interact with each other when subjected to impact and vibration. Moreover, due to the large non hanging mass, the suspension has poor cushioning performance and the vibration and impact of the vehicle are relatively large. The suspension is generally used for heavy trucks, buses and some other vehicles.

The leaf spring is usually used as the elastic element of the non-independent suspension, and since it also functions as a guiding mechanism, the structure of the suspension system is greatly simplified. Leaf spring suspensions are widely used in the front and rear suspension of trucks. The middle part is fixed with a U-bolt to the leaf spring on the axle. The front end of the suspension is a fixed hinge, which is connected by a leaf spring pin to the front end of the leaf spring and the leaf spring front bracket, and the front end of the ear hole has a bushing for reducing wear. The rear end of the lug is connected to the lifting lug through the leaf spring lifting pin and the rear lifting lug, and the rear end can swing freely to form a movable lifting lug. The distance between the two ears is subject to change when the frame is deformed by the impact spring.

2.2 Independent Suspension

The axle of the independent suspension is divided into two sections. Each wheel is independently installed under the frame or body with a spiral spring. When the wheel is beating, the other wheel is not affected. The ride stability and comfort of the car are better. But the suspension structure is complex and the bearing capacity is small. However, most of the front and rear suspension of modern cars have independent suspension, and have become the trend of future vehicle development.

The structure of independent suspension can be divided into various structural forms, such as candle type, Mcpherson type and connecting rod type, of which candles and Mcpherson shapes are similar. The two all combine spiral springs with shock absorbers, but there are significant differences in structure because of different structures. The candle type adopts the suspension form of the wheel moving along the main pin direction, which is similar to the shape of a candle. Their characteristics are that the kingpin position and the front wheel alignment angle do not change with the jumping up and down of the wheels, so that the handling stability of the vehicle is better. The McPherson is a suspension system of twisted sliding columns and lower transverse arms. The shock absorber can be used as a steering pin while the steering knuckle can rotate around it. It is characterized by the position of the kingpin and the location angle of the front wheel, which varies with the up and down of the wheel, which is exactly the opposite to the independent suspension. But the suspension is simple in structure, compact in layout and small in front wheel alignment. The independent suspension currently used on cars is Mcpherson independent suspension.



(a) Non-independent suspension (b) Independent suspension

Fig. 1 Simplified model diagram

3. Finite Element Analysis of Front Plate Spring Suspension

3.1 3D model Establishment

According to the size of leaf spring, three dimensional models of leaf springs were established by UG, and then the general model of leaf springs was established through assembly operation. As shown in Fig. 2.

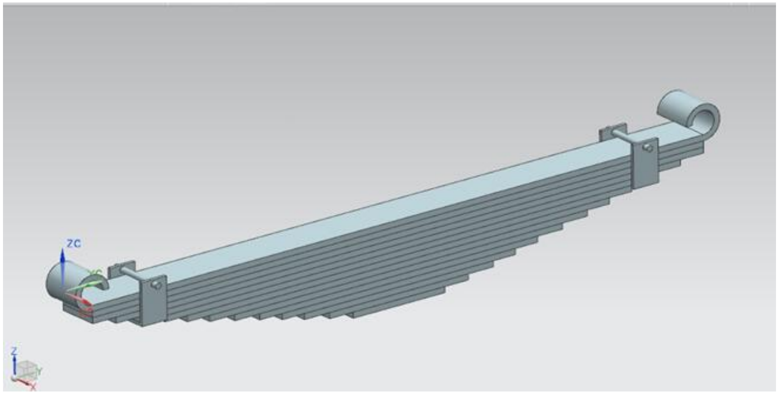


Fig. 2 Simplified model diagram of the leaf spring

3.2 Establishment of Finite Element Model

For ordinary leaf spring suspension with constant cross section blades, the vertical stiffness can be easily determined by means of material mechanics. But for the variable section leaf leaf spring, the effective and feasible method for calculating the stiffness and strength of the suspension is the finite element method[2]- [5]. By establishing the contact unit between the leaf spring piece and the piece, the vertical stiffness and strength of the leaf spring of any section are analyzed by hypermesh finite element software, and the arc height of the leaf spring assembly in the free state can be analyzed.

The CONTACT174 surface - surface contact unit was used to simulate the interaction between the surfaces of adjacent blades. The blade is meshed by SOLID95 solid unit, which is the high-order unit form of SOLID45 (3-dimensional 8-node). This unit can tolerate irregular shape without reducing accuracy. SOLID95 has 20 nodes, each of which has 3 degrees of freedom (X,Y and Z directions). This unit has arbitrary orientation in space and has the ability of plasticity, creep, radiation expansion, stress rigidity, large deformation and large strain. In the nonlinear finite element calculation, a large amount of resources are required, so under the premise of ensuring accuracy, the number of elements of steel plate spring should be as small as possible. The steel plate spring in this paper is divided into 1,066 SOLID95 elements and 8,203 nodes. The finite element model built by hypermesh finite element software is shown in figure 3.

Fig. 3 Spring plate finite element model

3.3 Material Attribute and Constraint Mode

The material of steel plate spring is 60Si2Mn, and its mechanical properties are shown in table 1.

Table 1 material properties and mechanical properties of spring springs

Material	Density ρ/g·cm^{-3}	Elastic Modulus E/MPa	Poisson's ratio υ	Ultimate strength(MPa)
60Si2Mn	4.5	1.10×10^5	0.3	1000

The two ends of the main leaf of the leaf spring are connected by lifting lugs, one end is a fixed lifting ear, and the other end is a movable lifting lug. The sliding mode is also used instead of the lifting lug. But no matter what kind of structure, the boundary displacement can be restrained by the support method of simply supported beam. Therefore, the constraints of x=0 and y=0 are applied in two directions along the chip length and the slice thickness respectively, and the constraint of y=0 is only applied along the slice thickness in the other direction.

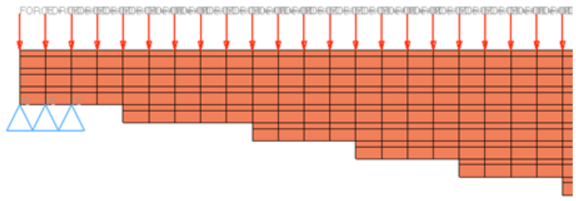


Fig. 4 Leaf spring constraint setting

3.4 Load Setting

A uniform load is set on each unit node on the upper surface of the first leaf spring, and the total load is half of the load on the front axle at full load, and the value is 13kN, as shown in Figure 5.

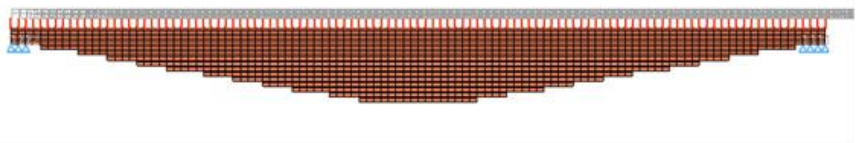


Fig. 5 Leaf spring load setting

Since the loading condition of steel plate spring under static load is studied, in the setting of load step, the loading type is set as linear static load, and the force and constraint are loaded into the loading step.

In order to obtain the deformation and convergence of the leaf springs under different loads, load is applied in step by step loading and then solved. The displacement of the center point of the upper surface of the leaf spring in the Y direction relative to the load 0 is taken as the deformation of the leaf spring.

4. Results Analysis

In the Radioss module, the stress distribution of the steel plate spring is shown in Figure 6. It can be seen that the stress in the middle part of the plate spring is larger and the stress on the two sides is gradually reduced, which is the same as the stress condition of the mechanical simple beam. It shows that the method is correct.

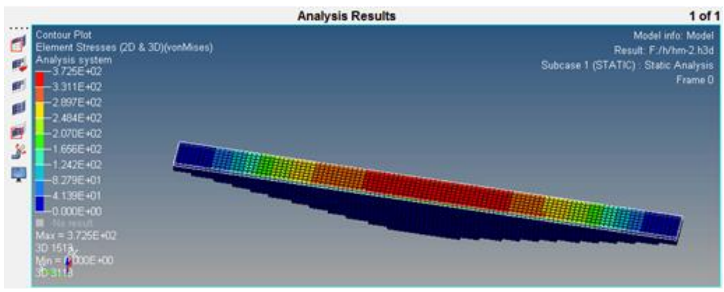


Fig. 5 Load stress distribution of leaf spring

5. Conclusion

Firstly, the structure of suspension is briefly introduced, and various factors influencing suspension motion are analyzed. The finite element analysis of the front plate spring suspension was carried out by using HyperWorks software. The mechanical properties of suspension can be obtained quickly, which makes the working technology simple. In view of the complex contact state, the type of contact can be analyzed, the suitable contact element is selected to discrete the grid unit, and the suitable element type is determined according to the actual contact condition. The exact convergence solution is obtained by the finite element numerical calculation method, which provides valuable data for the further design of the suspension spring suspension.

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