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Experiment and Simulation Study on Rolling Platform Tire Subsystem

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Abstract: By designing a dynamic impact test of tires, the "displacement - force" characteristics of tires under dynamic impact conditions are investigated to study the stiffness characteristics of tires under dynamic impact conditions. The accuracy and reliability of the tire finite element model are verified by the experiment. The tire model is transferred to the vehicle finite element model Simulation analysis of rolling platform. The simulation results show that the tumbling trajectory, the key structure deformation, the tire deformation and the acceleration curve of the platform rolling finite element simulation are basically the same as the experiment, and the influence of the tire subsystem on the rolling collision is verified.

1. Introduction

Tire is an important part of the car driving safely, is the only part of the car and the ground contact, to withstand the quality of the car itself and the load to maintain its movement performance, is the transmission of the impact of the road, with shock absorption, buffer energy and other effects [1-3]. Therefore, the tire performance has become one of the important evaluation indicators to measure the car level [4].

In the car rollover crash safety research, such as the American Standard FMVSS 208 rolling platform, car bias touch, the tire is the most important transmission path; Especially in the process of rolling platform, the tire first touch the baffle, the car is rolling due to inertia, the first contact with the ground parts, the dynamic stiffness will directly affect the tire performance, affecting the car's rolling attitude[5-7].

2. Tire Impact Test

2.1 Test Procedure

1) Tire posited: The tire and tire assembly are mounted on the impact tester to ensure that the size of the fixture on the test machine is comparable to the size of the fixture used in the vehicle. Adjusting the direction of the tire circumferential, ensuring that the impact of the site is in the bottom of the impact hammer.

2) Tire fixed: Hand-tighten the wheel alignment mounting nut to a predetermined torque value, Or with manufacturers recommended tightening manner, fixing the test tire.

3) Hammer height and counterweight quality adjustment: reference to "QC / T 991-2015" in the energy calculation formula, in order to obtain the required hammer test energy. Then, selecting the test parameter adjustment parameter table according to the energy. Adjust the impact plate height and weight according to the results.

4) Start the test, measure the data: releasing the hammer, carrying out impact, measuring the

displacement of the hammer in contact with the tire, And a contact force of the hammer to the tire during the impact. At the same time, using the system comes with tire pressure monitor to monitor the tire pressure changes.

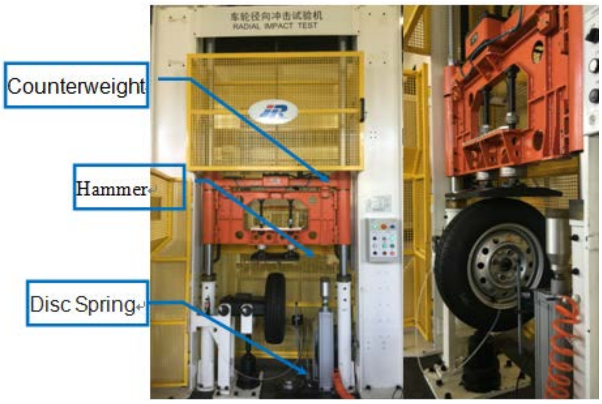


Figure 1 Schematic diagram of the experimental equipment

3. Simulation and Experimentation

3.1 Tire Modeling

As the wheel structure is complex, uneven thickness, in the tire finite element modeling, carried out a certain simplification. The model is divided into: tire outer surface, tire inner surface, tire side, rim surface, spoke and so on.

1) In order to better simulate the outer surface of the tire model, the outer surface consists of two layers of hexahedral solid rubber units. Wherein the solid rubber material selected model 27, the enclosure grid uses model 7 material. 2)The inner surface of the tire: the inner surface of the tire with quad shell unit simulation, using the model 1 material, through the common node connecting with the rubber body and the tire side.3) Tire side: Since the thickness of the side of the tire is variable, in the modeling, select the Tria shell grid, using model 1 material, through the co-node connecting with the tire inner surface and rims.4) Rim: Using quad-shell unit simulation, using model 24 material, to avoid the occurrence of tire balloon gap.5)Spoke: Using quad-shell unit simulation, the outer peripheral uses model 24 material, Internal for the simulation flange and other fixed parts using model 20 material.

3.2 Impact Simulation and Test Benchmarking

According to the finite element analysis process, the simulation model of tire and wheel dynamic impact test is constructed, testing the tire and wheel assembly model based on the test results, Figure 2 shows the tire impact test model with the tire model. It is the focus of this part of the study that the tires are part of the finite element model of rubber parts and rubber parts, and the different parameters such as material parameters and contact forms will have great influence on the simulation results.

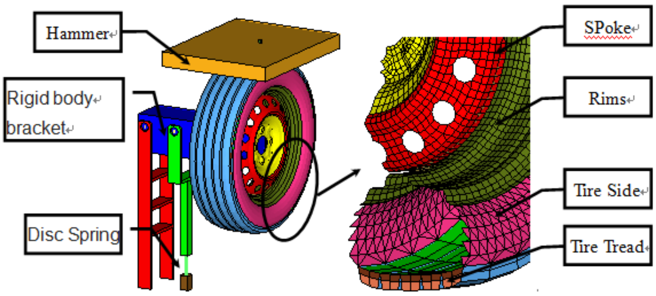


Figure 2 The tire impact test model with the tire model

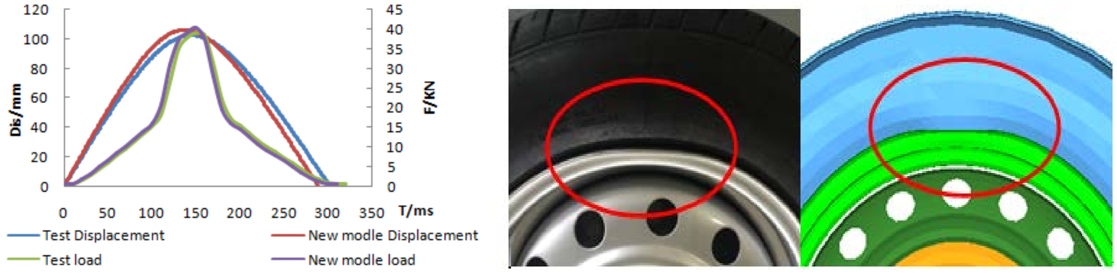
The "impact displacement - time" and "contact force - time" curves and the rim deformation are compared under the same energy impact condition in the experiment and simulation, as shown in

Figure 3. Through the comparison of the results, it can be found that the deformation of the rim is large, the deformation is 6.25mm in the experiment, and the deformation is 20.2mm in the simulation. The reason of the analysis is mainly because the original model of the tire side of the 2D type of unit for modeling, the actual side of the tire are not equal thickness structure, the use of 2D type unit simulation results are poor. Therefore, the tire side structure is reconstructed for this problem, and the tread grid unit is improved to reconstruct the tire model.

(a) The comparison of load and displacement (b) The deformation of the rim Comparative

Figure 3 The comparison of the original tire model simulation and test results

Therefore, the newly constructed of tire model uses 3D entity cells, which is more similar to the actual tire structure. In the new tire model, the MATL27 model was replaced by the MATL77_O model. Using the new tire model to re-simulate the simulation of tire impact test, Figure 5 shows the comparison of new model simulation and test results. In the new model, the deformation of the rim is 8.25mm,the displacement peak is 3.50mm and the load peak is 1.5KN. The deviation between the new model and the physical test is obviously reduced and the deviation is within the acceptable range. The tire model can meet the requirements of the vehicle rolling simulation.



(a) The comparison of load and displacement (b) The deformation of the rim Comparative

Figure 4 The comparison of newly constructed tire model simulation and test results

4. The performance of tires on the vehicle rolling platform

The "displacement - force" stiffness characteristics of the tire were obtained by tire impact test, and the finite element model of the tire was simulated by simulation. The new tire model is introduced into the vehicle to simulate the tumbling of the platform, and the influence of the tire on the safety performance of the platform roll collision is verified.

4.1 Roll attitude benchmarking

The key moment rolling attitude and the whole rolling platform process track more consistent, the simulation of the vehicle rolling two weeks, consistent with the test; The key motion in the selected state, the tire model validation and vehicle model accuracy are vivificated.

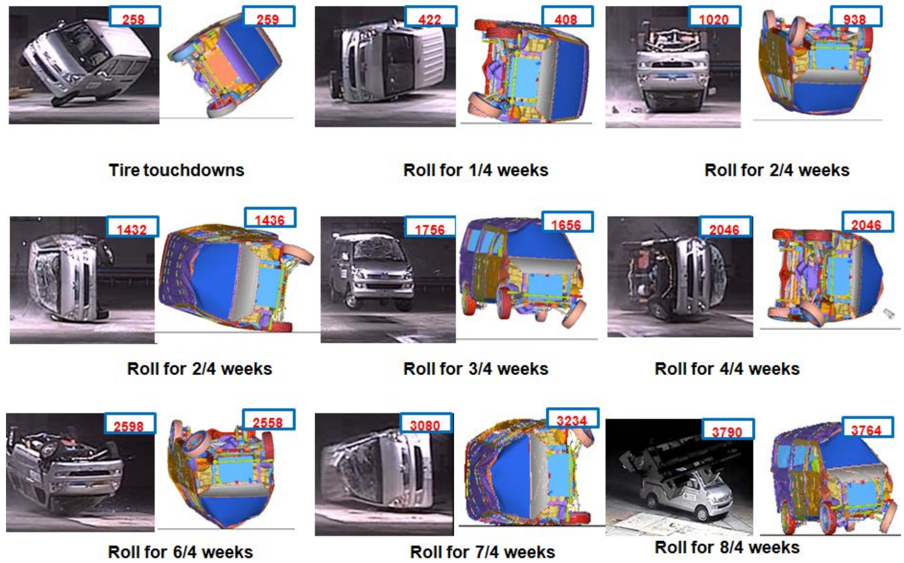


Figure 5 The comparison of the key motion gestures of the test and simulation vehicle.

4.2 Comparison of key structural deformation

After replacing the new tire model, select the large deformation of the finite element simulation and the main deformation structure in the experiment to see the deformation trend between the two forms, deformation, crushing deformation time is consistent.

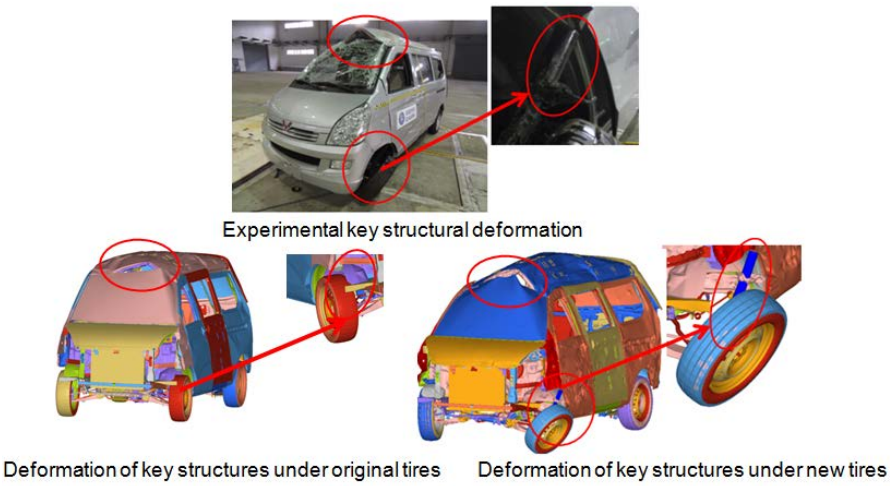


Figure 6 Comparison of key structural deformation

In summary, the platform roll simulation and experimental analysis shows that: the tire model can correctly reflect the platform rolling collision performance.

5. Conclusion

The accuracy and accuracy of the tire are verified by the simulation and experiment of the impact test and the platform roll simulation and experiment. The accuracy and accuracy of the tire are verified by the tire impact test and the "displacement - force" stiffness characteristic under the dynamic impact of the tire. The main conclusions are as follows:

1) By designing a dynamic impact test of tires, the "displacement - force" characteristics of tires under dynamic impact conditions were investigated. The tire refinement model is established. The accuracy and reliability of the tire refinement model are verified by the simulation and experiment of the impact test. The correctness of the tire refinement model modeling method is proved.

2) The accuracy of the rolling platform model is verified by the simulation and experimental rolling trajectory and the key structure deformation, and the influence of the tire on the safety performance of the platform roll collision is verified.

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