Finite Element Analysis of Emergency Spare Wheel Based on UG

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Abstract

This paper uses the software UG NX to establish the 3D model of emergency spare wheel, and employs UG senior simulation function to analyze the wheel structure stress , obtains the stress, strain and distribution cloud of displacement of the structure, it provides a reliable basis for the using reliability of emergency spare wheel.

Keywords

Emergency spare wheel, Finite element analysis, UG.

1. Introduction

With the development of industrialization and the improvement of living standard, more and more families have bought private cars. At the same time, the phenomenon of vehicle broking down occurs frequently, sometimes people can not safely replace the spare tire due to the lack of tools or personal reasons (especially women), so they have to wait for the rescue of trailer, but this method is expensive and time-consuming. In view of the above situation, there was a emergency spare wheel appearing on the market. Without having to replace the tires, people just need to drive the damage tire onto the emergency spare wheel, and bundle the damaged tire with the emergency spare wheel together, then the car can continue to run.

2. Overview of Emergency Spare Wheel

The emergency spare wheel is a new type of product which consists of five parts: universal wheels, vehicle body, fixing hole of tensioner, directional wheels and the automobile guide plate, as shown in Fig. 1. Vehicle body is molded by a new type of engineering plastics whose bearing performance is outstanding, the inner side of the body is designed with antiskid pattern, the use of antiskid pattern and tyre bundling belt tensioner(hereinafter referred to as "tensioner") can make the car wheel firmly fixed on the body which will increase the driving safety. The automobile guide plate is equipped with automatic springing and brakes. Plug the guide plate under the damaged car tire, and then drive the damaged tire onto the vehicle body. When the tire rolls to the guide plate, the brake device is in contact with the two directional wheels, and the directional wheels are "locked". When the tire is on the vehicle body, it is dissected with the guide plate, and the guide plate is automatically bounced off the ground. The universal wheels and directional wheels are made of wear-resistant polymer material which are reasonably matched to ensure the flexible steering of the car. Emergency spare wheel is suitable for use on cement and asphalt road from grade one to grade five.

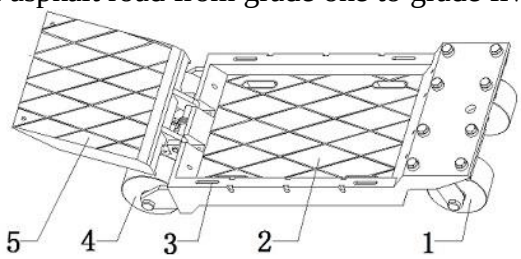

Fig. 1: schematic diagram of emergency spare wheel structure universal wheel 2. Vehicle body 3. Fixing hole of tensioner4. Directional wheel 5. Automobile guide plate.

3. Establishment of Finite Element Model of Vehicle Body

In order to make the car operate safely and reliably in any working conditions, the body structure should have sufficient strength and stiffness, so the design of the vehicle body becomes an important part of the whole design of emergency wheel. Finite element analysis of vehicle body structure is one of the main content of the structure design. Through the finite element analysis, people can the verify the rationality of the design, judge whether the car body structure satisfies the requirements of relevant standards or not, it also provides an important basis for the improvement of the vehicle body structure.

The principle of UG NX finite element analysis is to transform continuous data into finite elements, and set the discrete single elements into finite number of nodes.

Using 3D modeling software UG to establish the three-dimensional mathematical model of the parts, components and the whole vehicle, ignoring the details of the transition fillet, assembly process hole and others, so as to facilitate the division of the grid and save a lot of analysis time. The unit type adopts a 4 node tetrahedron entity SOLID92 with spatial irregular structure characteristics because it is suitable for the emergency wheel model, body material is engineering plastics whose elastic modulus is 3000000mN/mm^2 (kPa), density is 1.05e-006kg/mm^3, poisson's ratio is 0.35. The free wheel meshing method is used in the advanced simulation of the body of the emergency wheel, which takes full account of the curvature of the geometric figure and the proximity between line and line. The small bolt hole, micro convex, vehicle body chamfer, fillet and other parts which do not affect the finite element quality and calculation accuracy are simplified. A total of 737781 units and 177147 nodes are drawn, and the finite element mesh division of the vehicle body structure is shown in Fig.2.

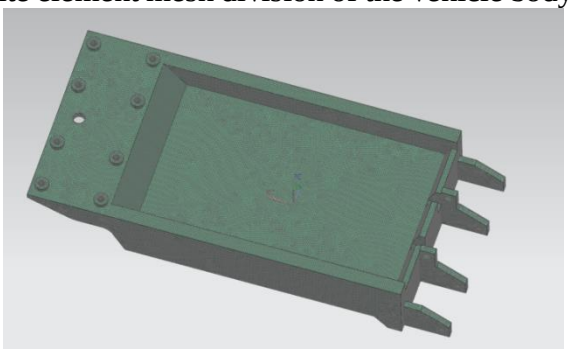

Fig.2 the finite element mesh division of the vehicle body structure

4. Load and Solution of Basic Load

The total weight of the emergency wheel is 6kg, and the weight of the vehicle body is 3.5kg. Emergency spare wheel body shares a quarter of the total weight of the car, about 500kg. Suppose the use of emergency spare wheel is divided into two types: running on a horizontal road or on a slope road.So This paper analyses the two situations .

4.1 Analysis of Running on Horizontal Road

When the emergency spare wheel running on the horizontal road, set the fixed position of emergency spare wheel to be fixed constraint, apply a vertical downward force of 5000N on top of the vehicle body ,set the gravity as 9810m/sec^2, select SOL 101 type linear static-global constraint as solution scheme type solve them. The vehicle body deformation is shown in Fig. 3, and the stress distribution of the vehicle body structure is shown in Fig. 4.

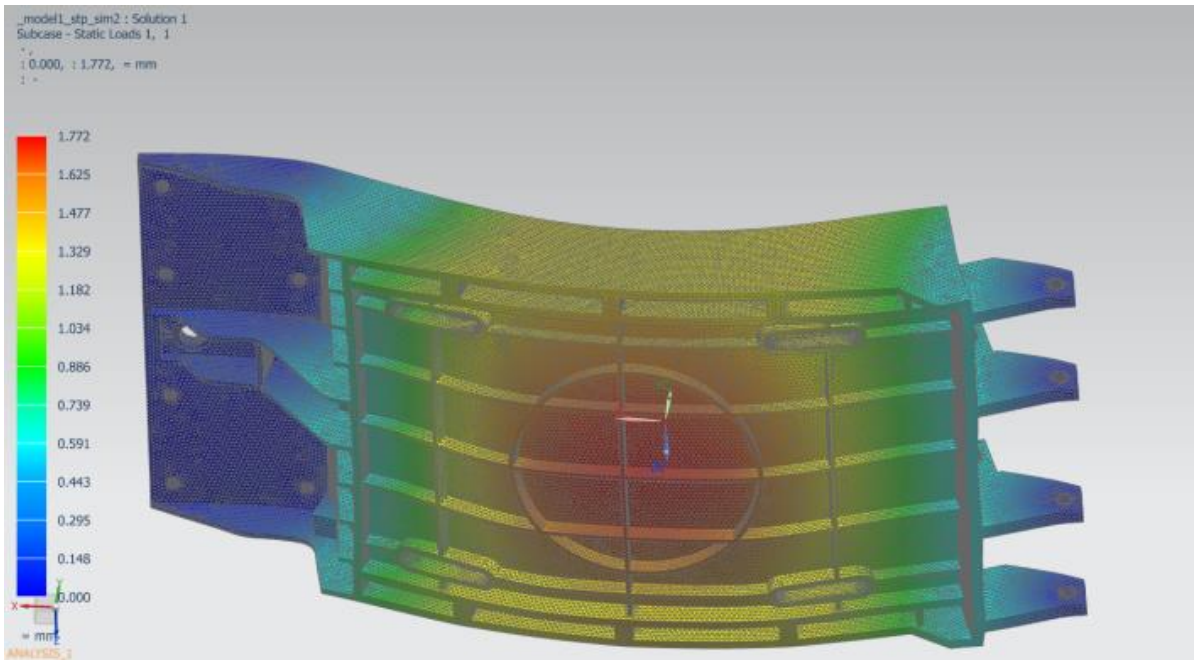

Fig. 3 deformation diagram of vehicle body

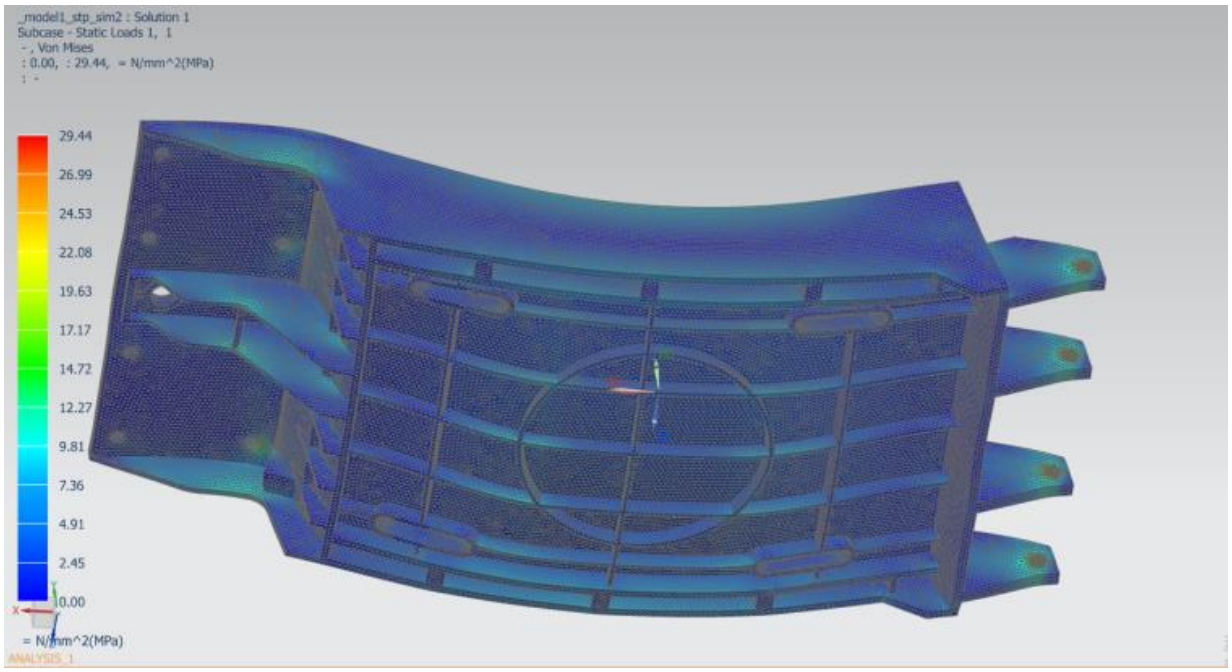

Fig. 4 stress distribution diagram of the vehicle body structure

From vehicle body structure deformation Fig.3, it can be seen that after loading the maximum deformation displacement of the vehicle body is 1.772mm,which is within the allowable range of the deformation of the vehicle body. From stress distribution of the vehicle body structure Fig. 4, it can be seen that the maximum equivalent stress of the vehicle body structure is 29.44 MPa and most of the region's equivalent stress is 7.36MPa.They are far less than the ultimate stress 80MPa, according to the safety coefficient formula: N=maximum equivalent stress/limit stress, safety coefficient N= 2.72, so the design of the vehicle body structure satisfies the requirements of strength and rigidity.

4.2 Analysis of Running on Slope Road

When emergency spare wheel running on the slope road , assuming the slope gradient to be 30 °, that is $\theta = 30^{\circ}$, the force analysis of the rear wheel of the emergency spare wheel is carried out to verify whether the strength of the wheel joints satisfies the requirements.

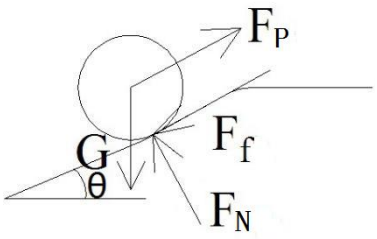

Fig. 5 stress analysis diagram of rear wheels of emergency wheel

$$F_f = \mu \cdot F_N = 527.4N$$

$$F_P = F_f + G \cdot \sin\theta = 1035N$$

Still set the gravity as 9810m/sec^2, select SOL 101 type linear static-global constraint as solution scheme type, apply a vertical downward force of 5000N on top of the vehicle body. On the basis of these, apply a tilting force $F_P = 1035N$ on the rear wheel as shown in Fig. 5, divide the grid and get the solution.

After the wheel is hidden, the deformation of the connection part is shown in Fig. 6, the stress distribution of the connection part is shown in Fig. 7.

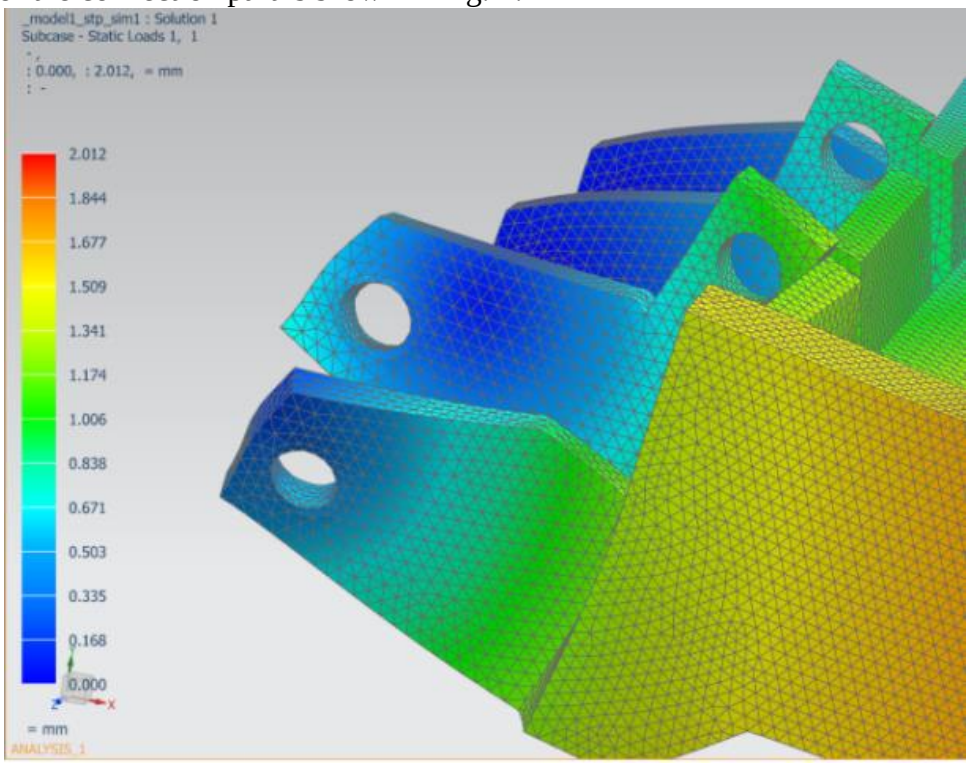

Fig. 6 deformation diagram of the connection part

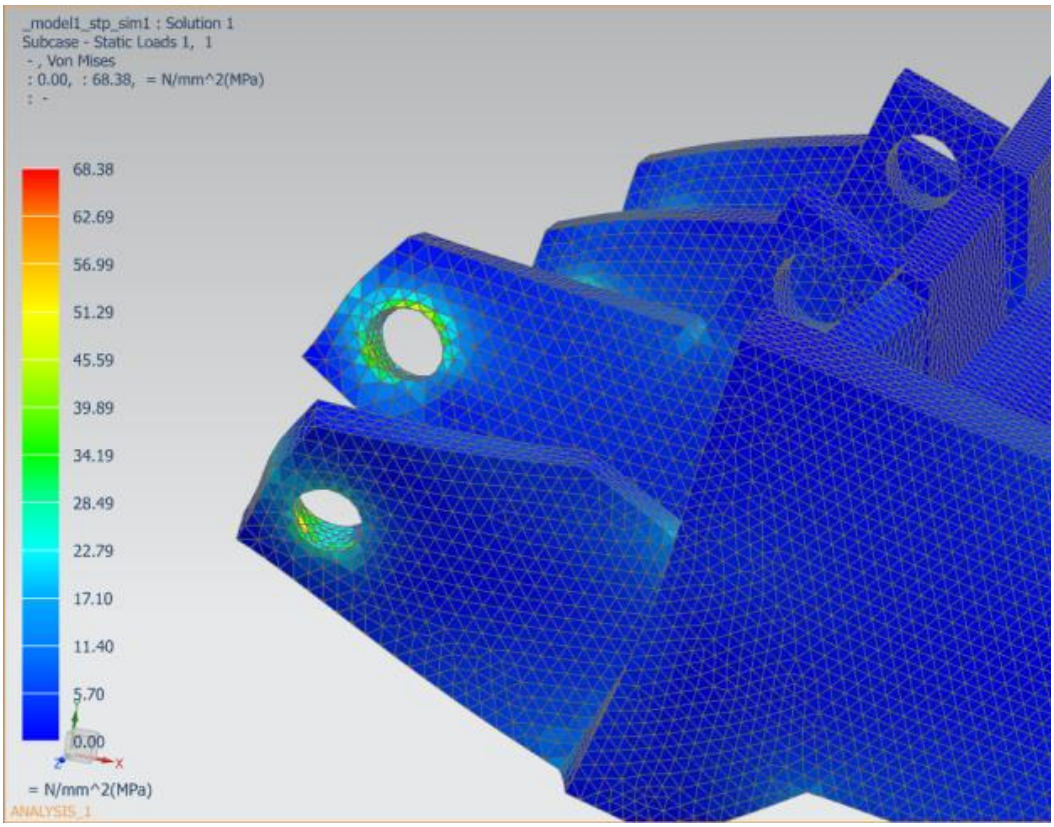

Fig. 7 stress distribution diagram of the connection part

From the diagram of deformation of the connection part Fig.6, it can be seen that after the dynamic load the maximum deformation displacement is 2.021mm which is within the allowable range of the structural deformation of the emergency spare wheel. From the stress distribution diagram of the connecting part Figure 7, it can be seen that the maximum equivalent stress of the body structure is 68.38MPa, the equivalent stress of the other part is about 50MPa. Both of them are less than the limit stress of 100MPa, so the design of emergency spare wheel connecting structure satisfies the requirements of strength and stiffness.

5. Conclusion

Based on UG NX software, this paper analyses the car body of emergency wheels, and simulates the key part of the connection separately, obtains the equivalent stress deformation and deformation of the body structure, intuitively reflects the distribution of stress and displacement, the results show that the design of strength and stiffness of the body structure can both satisfy the requirements of work. It provides an important basis for the using safety, reliability of emergency spare wheel.

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