# Static Analysis of Front Axle of Electric Tractor Based on ANSYS Workbench

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## Abstract

**In order to rapidly develop electric tractors and solve the problem of long design period of electric tractor front axle, this paper loads 3 times of net full load axle load of pure electric tractor designed according to the front axle model of existing 25.7kW fuel-powered tractor. According to the existing tractor front axle detection standard, the ANSYS Workbench is used to analyze its static characteristics. It is found that the front axle meets the static mechanics requirements of electric tractors and can meet the normal use of electric tractors.**

## Keywords

**Electric tractor,front axle,static analysis.**

## 1. Introduction

In recent years, the pressure on the environment has increased, and the state's environmental management is imminent. China is a big agricultural country, and agricultural machinery occupies an indispensable position in the motor vehicle market. However, agricultural machinery does not use resources efficiently. Tractor, as a power source in agricultural machinery, occupies a large market share of agricultural machinery. Therefore, the development of pure electric tractors is an effective way to solve today's environmental problems. However, China has a short research time for pure electric tractors. The design and production cycle of new structural parts is long, the design and development time is long, and the cost of use is high. Therefore, a large number of meets the requirements in a limited time. The front axle of a pure electric tractor is impractical. In addition, for the electric axle front axle, which is still immature and inexperienced, the method of modification, experiment and optimization based on the traditional fuel-powered tractor structure is undoubtedly an effective way for rapid development. 60% of the power battery pack is placed at the front of the tractor, thus increasing the load on the front axle of the electric tractor. Strength Check. [1,2,3] In this paper, the design load of the electric tractor is loaded onto the front axle structure of the traditional fuel-powered tractor. The ANSYS workbench is used for static analysis to see if the results meet the design requirements.

## 2. Front axle static analysis

### 2.1 Model establishment

The specific parameters of the 25.7 kW electric tractor designed in this paper are shown in Table 1. The front axle uses the SF400E tractor front axle, and the front axle assembly uses three bell-shaped tubes, the size is 90*73*R36.5*85.5mm, and the bell tubes are bolted together.

Table 1 Electric tractor parameters

| Vehicle weight | Front and rear axle load ratio | Front axle load | Track |
|---|---|---|---|
| 2000Kg | 2:3 | 800Kg | 1300mm |

This paper uses SolidWorks 3D modeling software to model the SF400E front axle, and ANSYS Workbench provides a powerful geometric CAD interface. The front axle entity is directly saved after assembly. In the Workbench interface, the saved physical module can be directly opened to realize

SolidWorks and Workbench. Interconnection. In the modeling process, the model should be simplified in an appropriate amount, and it is necessary to require less time and computation to ensure higher calculation accuracy. For some dangerous parts, the details of the original actual structure should be retained as much as possible to accurately reflect the influence of the dangerous part and the specific structure on the stress of the bridge shell. On the other hand, it is necessary to simplify the detailed structure of the non-hazardous part. Reduce the number of finite element model nodes and save computation time [4].

### 2.2 Finite element analysis process.

First meshing. When the front axle of the tractor is built into a finite element model, the mesh is divided into different forms (the specific number of meshes, the degree of mesh density, the height and low of the cell order, the good or bad of the mesh quality, etc.), and the final result will be The results did have a big impact. The smaller the cell size, the higher the mesh quality and the higher the accuracy of the resulting final result. However, the excessive number of cell grids leads to a large computational scale and may result in computational failures, and the calculations take a long time [5]. This paper uses a tetrahedral-based partitioning method. First, set the Element size for the entire structure. Considering the effect of the global mesh size on its results, set the Element size to 5mm. Then, the mesh is refined on places with large force, corners, and contact surfaces between the parts. Considering that the force of the fist parts at both ends of the front axle may be concentrated, the surface contact between the bell tubes of the assembly and the intermediate support pin holes and the rib portions may be greatly deformed by force, and the mesh is fined on the above parts. Set the Element size to 3mm, and the meshing result is shown in the figure. The total front-axis model has a total of 967,968 nodes and 639,922 units. After the division, the grid quality should be tested, and the result is required to reach some indicators. This paper uses the grid statistics of ANSYS Workbench to detect the Element Quality. The average quality of the detection result grid is 0.76303, which meets the mechanical parts in the finite element. The result of the grid quality greater than 0.7 when analyzing.

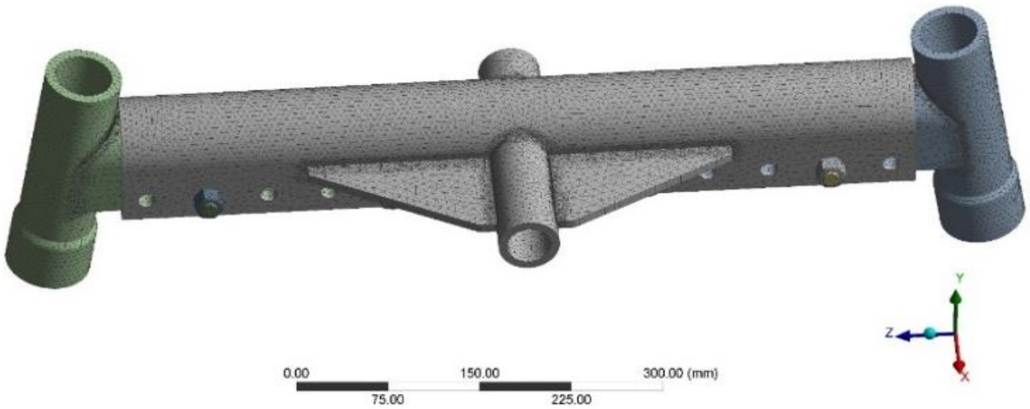


Figure 1 front-axis model meshing results

### 2.3 Boundary condition setting for finite element analysis .

In the actual work process, the working mode and working environment of the tractor are very complicated. The non-driven front axle of the tractor is connected to the front carrier by only one pin. When the left and right wheels are running on uneven roads and working in the field, the front axle will swing up and down and increase the dynamic load. Refer to the agricultural vehicle drive axle design test standard, the upper limit load of the drive axle is 3 times the net full load axle load. Combined with the design standard of the electric tractor, this paper sets the dynamic load K=3 of the front axle of the electric tractor. According to the design weight of the pure electric tractor and its front and rear axle load distribution, when K=3, the load loaded on the front axle is calculated to be 2400Kg, which is about 2.4KN. From the actual force analysis, the axle load is loaded on the connecting king pin hole. According to the analysis of the actual force movement of the front axle of the tractor, the left main pin hole is fixed in the X, Y and Z directions, and the right main pin hole is constrained in the X and Y directions. The material is selected as Q345, and its material properties are as shown in Table 2; in the calculation process, its own gravity cannot be ignored. The mass of the front axle measured in ANSYS Workbench is 21.7kg, and the direction of gravity acceleration is opposite to the direction of gravity.

Table 2 Q345 material characteristics

| Material | Elastic Modulus /GPa | Poisson's ratio | Density /Kg/$m^3$ | Yield strength /MPa |
|---|---|---|---|---|
| Q345 | 206 | 0.28 | 7850 | 345 |

### 2.4 Analysis result.

After loading the solution, the force cloud of the front axle subjected to 3 times the net full load axle load is shown in the figure below. Since the front axle is a symmetrical structure, only one side of the analysis is needed in the analysis.

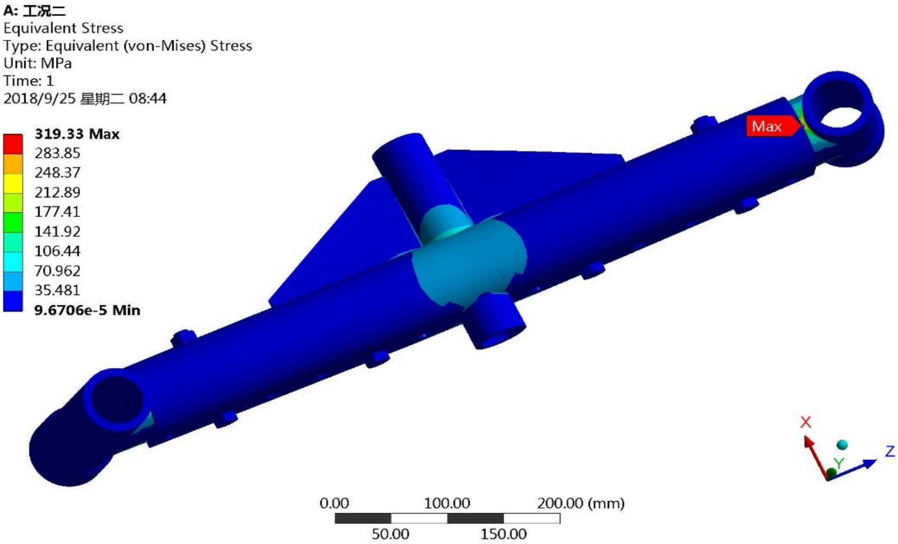


Fig.2 Front axle overall force cloud map

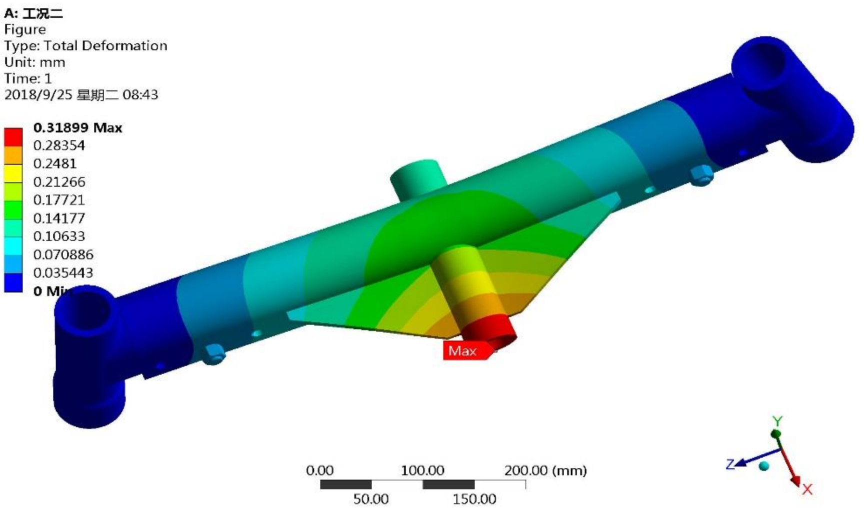


Fig. 3 Front axis overall deformation cloud

As a result of analysis, it can be seen from the analysis result of Fig. 2 that the most stressed part of the entire front axle assembly is concentrated on the fist portion at both ends of the front axle, that is, the joint portion of the main pin hole and the bell tube, the main reason is due to There is a transitional connection between the main pin hole and the bell tube, the stress is easy to concentrate in the region, and since the front shaft is a combined structure, the joint is a relatively weak portion, so the maximum stress occurs at the place, and This is where the intermediate part is connected to the left and right half-shaft sleeves, and intersecting lines appear, where stress is also easily concentrated. It can be seen from the analysis of the front-axis strain cloud of Fig. 3 that after the front axle is subjected to stress, the maximum comprehensive displacement value is at the longest end of the connecting pin hole. This is because the force is strong at this place, and the force arm is long. Although the left and right sides of the pin hole are fixed by the ribs, the limitation is mainly the left and right displacement, and the restriction on the displacement of the connecting pin hole. There are certain limitations.

Analysis of the stress and strain cloud diagram of the front axle shows that the maximum stress of the front axle is 319.33 MPa and the maximum comprehensive displacement is 0.32 mm under the full load of the tractor front bearing. The maximum bending limit of material Q345 is 345MPa, and the maximum stress of the front axle assembly is 319.33<345 MPa. The front axle can meet the requirements of material use and can be used normally. According to relevant standards, the maximum deformation of the front axle when full load is applied. It can't exceed 1.5mm/m; the maximum deformation of the front axle is 0.32mm/1.3m=0.25mm/m<1.5mm/m. Under the full load condition, the maximum deformation is the test standard [6].

## 3. Conclusion

According to the static analysis, the front axle of the fuel-powered tractor is applied to the electric tractor. When the front axle is subjected to 3 times the net full load axle load, the maximum stress is 319.33 MPa, which is smaller than the yield limit of the front axle material and can meet the use of electric tractors. The maximum deformation is 0.32mm, which meets the relevant testing standards of tractors. The research methods mentioned in this paper can also provide a feasible method for the design of other parts of electric tractors in the future.

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