ISSN: 2664-9640

Design and Analysis of the Saddle Under Auxiliary Braking of Heavy Goods Vehicle

Zhizhong Lv[1] and Qingkuan Lin[1]

[1]Southwest Petroleum University, Sichuan 610500, China.

Abstract

Tractor saddle is the only connecting element between semi-trailer and tractor, which plays an important role in the stability of the whole vehicle.This paper mainly introduces the establishment of geometric model of tractor saddle and mesh division based on experimental data.Its strength and stiffness directly affect the connection stability of the tractor semitrailer and the safety of the whole vehicle.This paper mainly studies whether the structural strength and stiffness of tractor saddle under pressure meet the requirements.

1. Einleitung

Today, in the era of efficient transportation efficiency, the driving speed of heavy-duty semi-trailer is usually above 80km/h. When braking occurs on slippery roads or on curves, sideslip, tail-throwing and folding of vehicles are easy to occur. In recent years, due to the fault of brake failure caused by excessive heat from the long time of active braking, more and more auxiliary braking devices are assembled in heavy semi-mounted vehicles, such as exhaust braking, electromagnetic retarder and hydraulic retarder, and achieve good results in the long downhill braking. However, due to the structural particularity of heavy semi-trailer vehicles, the auxiliary brake can only act on the power source, that is, it can only act on the driving wheel of the tractor, not on the semi-trailer truck. With the intervention of the auxiliary braking force, the distribution of braking force has changed greatly. The tractor saddle is the only connecting element between the semi-trailer and the tractor. Its strength and stiffness directly affect the connecting stability of the semi-trailer of the tractor, and also have a great influence on the safety of the whole vehicle. In the finite element static analysis, inertia and damping are not taken into account, and the stress and displacement of the structural parts of the tractor saddle under static load are mainly calculated in the static state, semi-trailer full load state, and whether the design meets the requirements of national standards and lightweight. This chapter mainly studies whether the structural strength and stiffness of the tractor saddle under pressure meet the relevant provisions of the test of "road vehicle-traction seat strength", and prepares for the analysis and research of the auxiliary braking condition in the future.

2. Tractor Saddle Model Created

2.1. The Establishment of Three - Dimensional Model

Take a page from joss. The special saddle JSK37 is made of ductile iron and model # 50. The main dimensions and connection dimensions of the saddle according to the standard DIN74081 are shown in figure 1

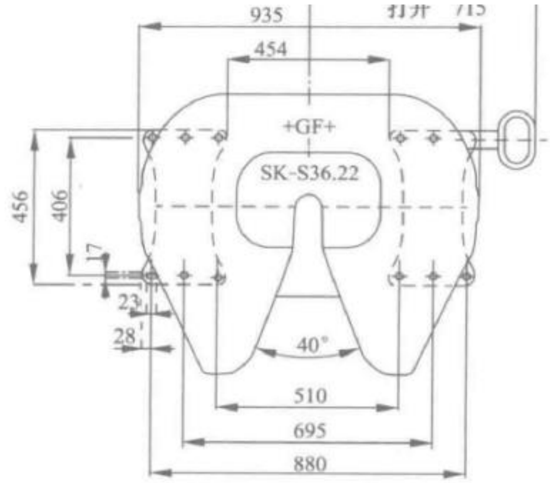


Figure 1. National standard size

2.1.1 3d model of saddle body box

According to the structure size shown in figure 1, solid work software was used to build the model. The modeling idea was:

(1) First to deal with the main saddle mill, in today's saddle mill use present situation, it's on the wear and tear is bigger, need to add lubricating oil in use around January, mainly to the use of lubricating oil is very low, there is no oil mill system, therefore, on the mill design a depth of 3 mm width is 25 mm 3/4 ring type lubricating oil ring, and the two key on the front end design to increase lubrication and oil storage area of the front.

(2) Nowadays, the main way to add lubricating oil to the saddle is to separate the semi-trailer from the saddle and manually apply lubricating oil on the panel, and then connect the saddle with the semi-trailer, which is time-consuming and laborious. In this structure, an oil storage groove and a lube oil mouth were set on the surface of the grinding disc, and the influence of this structure on the grinding disc was analyzed later.

(3) The front end of the traction seat bears a lot of variable loads, and the bending of the saddle in current use is mainly in the front end, so five support plates are added at the bottom end to support it.

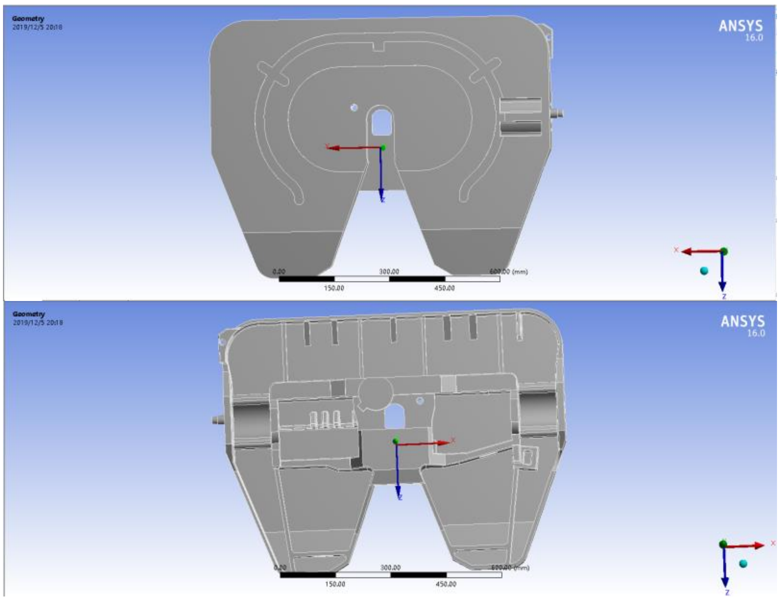


Figure 2. Three-dimensional model of the saddle

ISSN: 2664-9640

2.1.2 A three - dimensional model of the sleeve buffer

When tractor and semi-trailer through saddle connection, mainly through the saddle support direct connection with saddle holes connection, the up and down for a long period of time under the impact load is bound to the connection between the hole and bearing wear, bearing is a product of form a complete set, easy to change, but the connection hole is a integrated with saddle stents, cannot replace alone, so in the connection hole and bearing support design a socket buffers, connect the saddle bracket hole with saddle fixed connection into flexible connection, in turbulence when tractor saddle following tractor swing car body, reduce the torque of the tractor and chassis, protect the tractor saddle mill.

The three-dimensional structural model of the sleeve buffer was created by software solidwork and saved as. X_t format, imported into ansys, and modified appropriately, as shown in figure 3

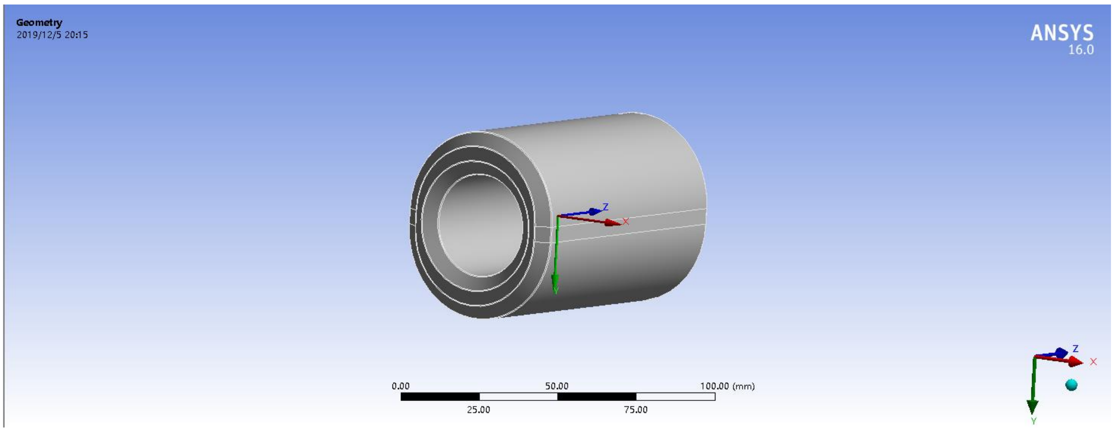


Figure 3. Sleeve buffer model

2.1.3 Tractor saddle support

The tractor frame, as a saddle, is connected to the tractor frame as two components, and the calculation of its strength and fatigue strength is also very important, so the establishment of its model is also very important. The diameter of the axial bearing part is set as 16mm.

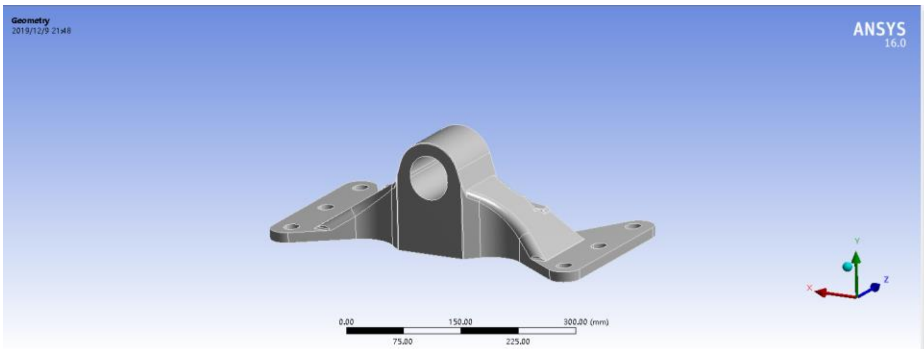


Figure 4. Saddle support model

2.2. Model Checkillg

This chapter is mainly the tractor saddle static load conditions of the test model of stress and strain before processing, so do the 3 d model of saddle simplified treatment:

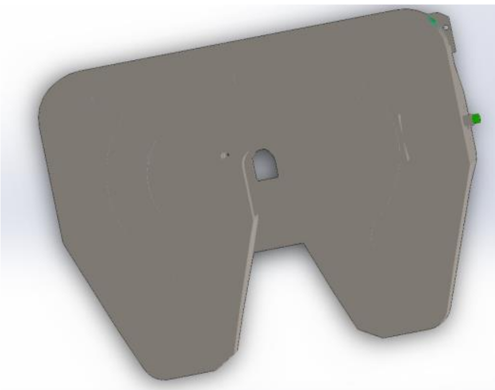
(1) simplify the fillet processing saddle plane board, already achieved the purpose of reduce the difficulty of meshing;

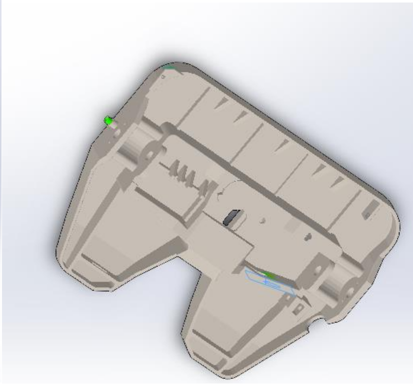
(2) remove the lubricating oil orifice design, because it is a multi-gradient cylinder design, the accuracy of grid generation needs to be higher, but it has little impact on the calculation results of plane static load, so it is selected to be removed;

(3) the model of locking mechanism and the fixed structure part of the chain is removed. The effect of locking mechanism on the static load of the saddle can hardly be calculated, and the structure of locking mechanism is relatively complex. Considering the running ability of the computer, this structure is also omitted;

2.2.1 Thin-walled check

Prior to the introduction of solid work model into ansys, the corresponding geometric processing of details should be carried out on the model. Firstly, the simplified model should be checked for thin walls less than 3mm. During the modeling process, whether there are such errors and whether there are thin walls on the main loading surface should be checked





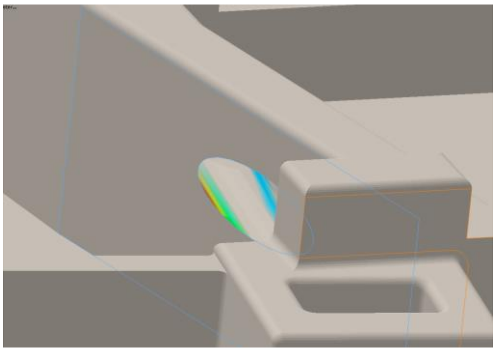


Figure 5. Geometry inspection

After inspection, there was no thin-wall feature on the loading surface, only thin wall appeared at the lubricating oil filler port, locking device spring and gripper, which had little effect on the result.

2.2.2 Geometric analysis

The built-in plug-in of Solidwork software is geometric analysis. Geometric analysis can identify the set entity in the part that causes the problem in ansys. Geometric analysis can identify thin, small, short edge, sharp edge and vertex, intermittent edge and surface.

The tractor saddle should mainly check the thin surface, short edge line and intermittent surface. Thin surfaces are mainly checked if they are less than 0.1mm, sharp edges and sharp vertices are selected if they are less than 3 degrees, and intermittent geometry is checked at the same time.

It can be seen from the inspection results that there are mainly 2 short edges, 1 thin thin surface and 19 sharp vertices. 2. The short edge line is 0.02mm, which is the interface of the locking device and does not bear load, so it has no influence on the structure. 1 thin surface also appears here, the reason for its appearance is that the two circles are tangent to each other, and it does not bear the load and affect the structure. After checking the 19 sharp vertices, they all appeared at the junction of the bottom panel and the transverse structure, and the rounded corners were disposed of in the later finite element analysis, so there was no problem with the 3d model built.

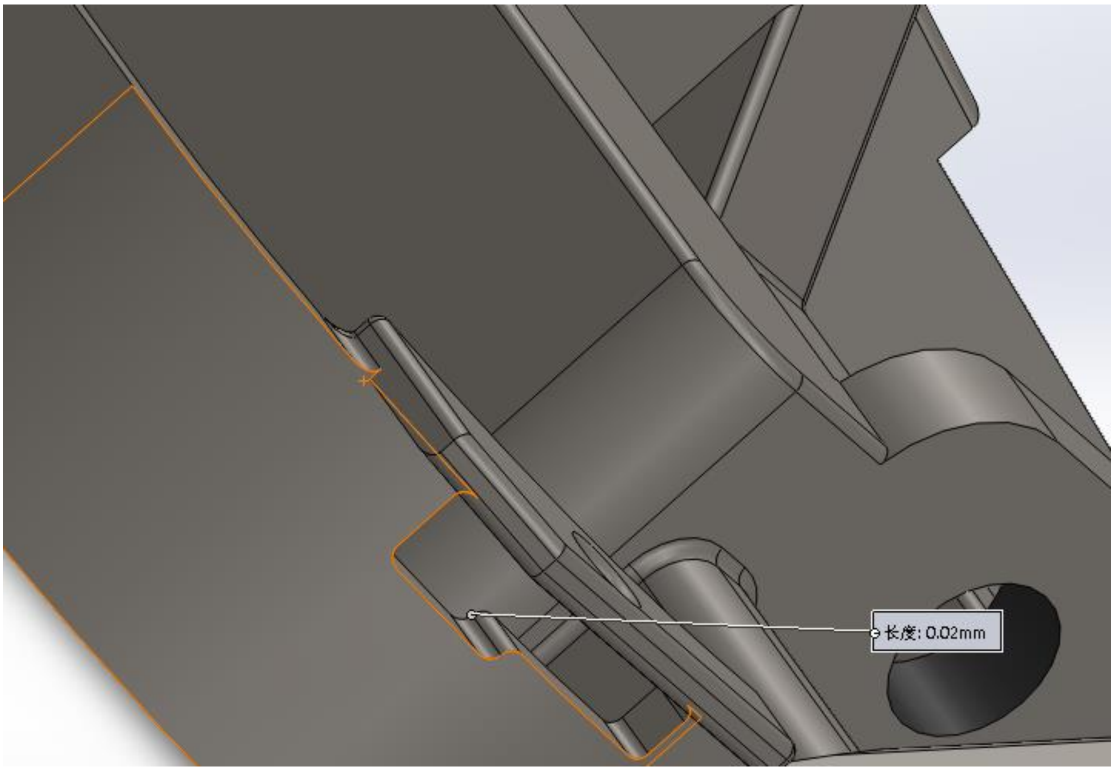


Figure 6. Thin-walled inspection results

3. Finite Element Static Analysis of Tractor Saddle

In the finite element static analysis, inertia and damping are not taken into account, and the stress and displacement of the structural parts of the tractor saddle under static load are mainly calculated in the static state, semi-trailer full load state, and whether the design meets the requirements of national standards and lightweight.

3.1. The Basic Theory of Static Analysis

In the static analysis, the analysis of the static structure is originally a linear static structure analysis, and the displacement is solved by the following matrix equation:

$$[K]\{D\} = \{F\}$$

[K] Is a constant matrix, a structural stiffness matrix composed of the element stiffness matrix. Its assumptions are as follows: it is assumed to be the behavior of linear elastic materials.

{D} is a node displacement array structure consisting of whole displacement vector

{F}is the external load vector formed by the force matrix acting on each node, which is statically loaded on the model, without considering the force changing in years and time, and without considering the influence of inertia.

The structural integral vector {D} obtained from the solution process can be used to obtain the stress and displacement of each finite element unit grid.

3.2. Static Analysis of Saddle Body Box

3.2.1 Calculation of load distribution

ISSN: 2664-9640

The contact surface between the trailer and the tractor saddle is the upper surface, the trailer is the lower surface of the chassis, the traction pin and the tractor saddle are in full contact after being fixed, and the upper surface of the tractor saddle is a flat surface, so the force is uniform at rest. The trailer's total weight is 39T and the tractor is 10T when full load, which meets the standard load of the six-axle vehicle under the national standard.

When the semi-trailer is fully loaded, apply 40% of the weight under the tractor saddle, i.e. 16000kg, the applied direction is minus Y

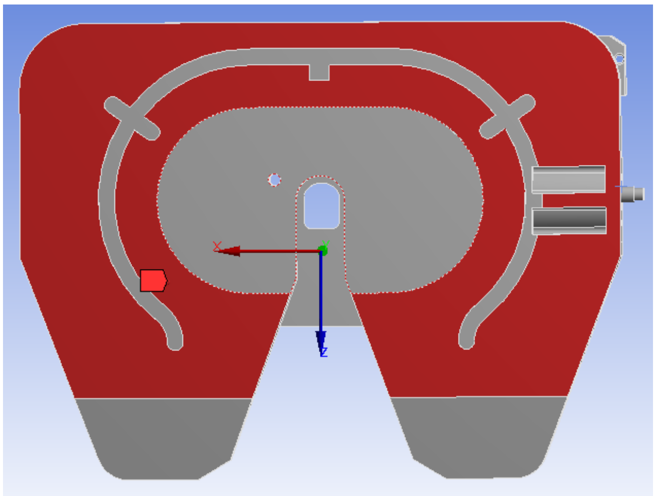


Figure 7. The applied surface and direction of the load

3.2.2The division of finite element mesh

Material properties are added in ansys, and the main board of tractor saddle adopts 16Mn strength alloy steel, namely Q345. The material properties of Q345 are shown in the following table:

Table 1. Material properties of Q345

poisson ratio	density	Elasticity modulus	yield strength	Strength of extension
0.3	7.8E-06kg/mm3	2E11	345MPa	510MPa

The sleeve buffer adopts 20Cr, and its material properties are shown in the following table：

Table 2. Material properties of Q345

poisson ratio	density	Elasticity modulus	yield strength	Strength of extension
0.254	7.8E+11kg/mm3	2E11	550MPa	850MPa

The hexahedral element was selected in the grid element, and automatic mesh division was adopted in the static analysis. The result was 3318,438 cell nodes and 2178,234 grids. The grid quality was as expected, as shown in figure 8, to prepare for the next step of static simulation.

ISSN: 2664-9640

Statistics	
Nodes	3318438
Elements	2178234
Mesh Metric	Element Quality
Min	8.6204e-002
Max	1.
Average	0.82559
Standard Deviation	9.9561e-002

Figure 8. Mesh Quality

After continuous improvement, the model after the final grid division is completed is shown in figure 9 and 10

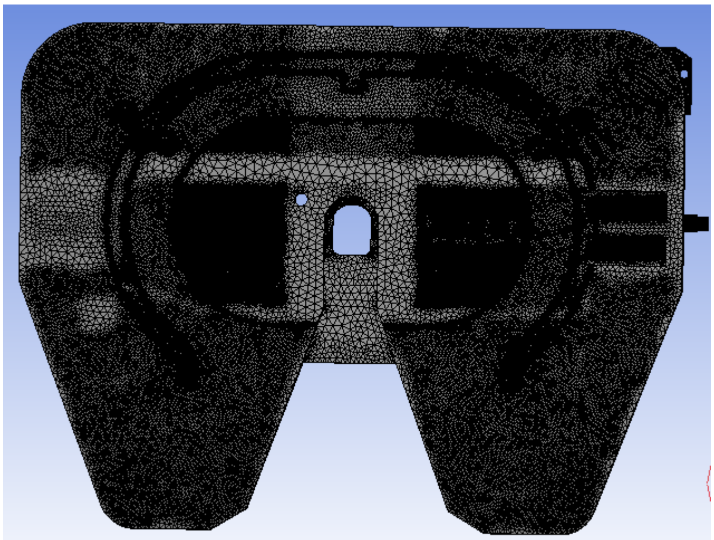


Figure 9. Saddle panel front mesh model

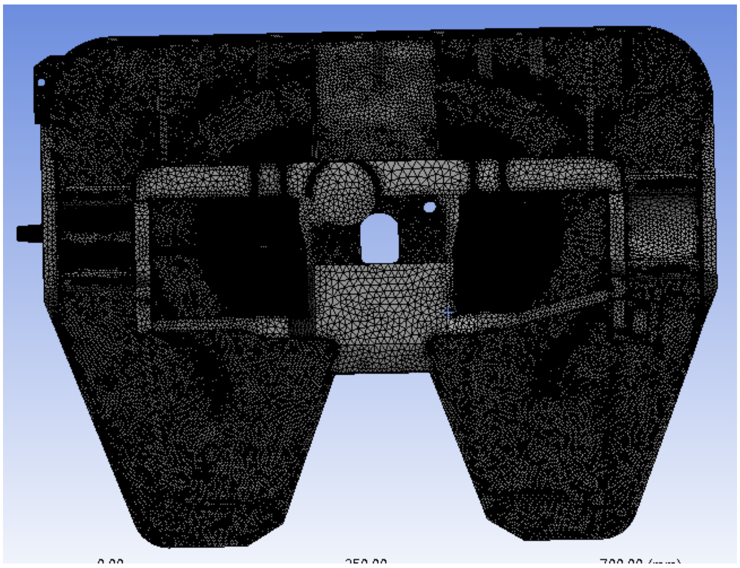


Figure 10. Grid model on the back of the saddle panel

3.2.3 Constraints and boundary conditions

ISSN: 2664-9640

The tractor saddle and the tractor saddle abutted type are connected through the axle sleeve, so the circumference constraint is applied to them to restrict the degree of freedom of movement of XYZ, and only the degree of freedom of rotation in the direction of YZ is allowed at the joint, as shown in figure 11.

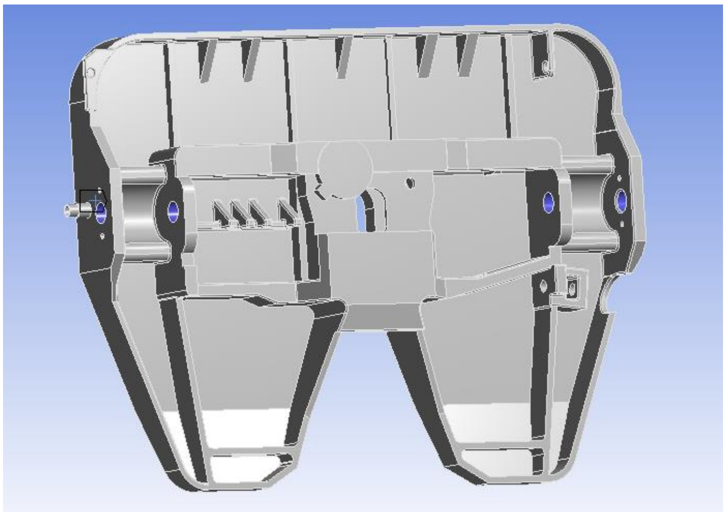


Figure 11. Circumferential constraint of tractor saddle

3.2.4 Result analysis and processing

After setting constraints and loads, the displacement and stress cloud diagram of tractor saddle is obtained through analysis, as shown in figure 12 and 13

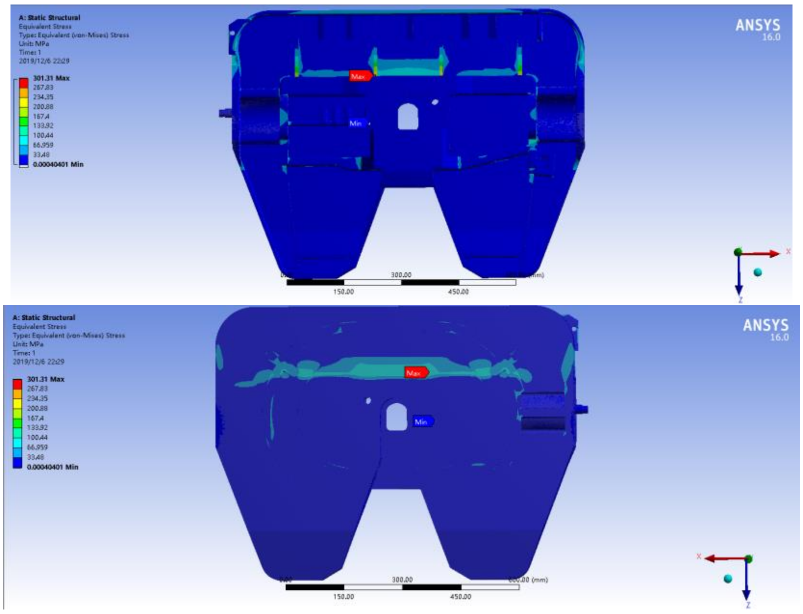


Figure 12. Tractor saddle stress cloud diagram

According to the results of the analysis, under the action of evenly distributed static load, the maximum stress value of the stress received by the tractor saddle between the intermediate box and the welding seam at the upper end below the box body is 301.3mpa, and the yield strength of small Q345 is small. Therefore, the light weight of Q345 material meets the requirements and conforms to the relevant safety requirements of national standards. In addition, the vertical support plate is a thin plate relative to the upper support plate, and stress concentration is easy to occur here. According to the feedback of actual saddle use, it is also damaged at the welding seam here.

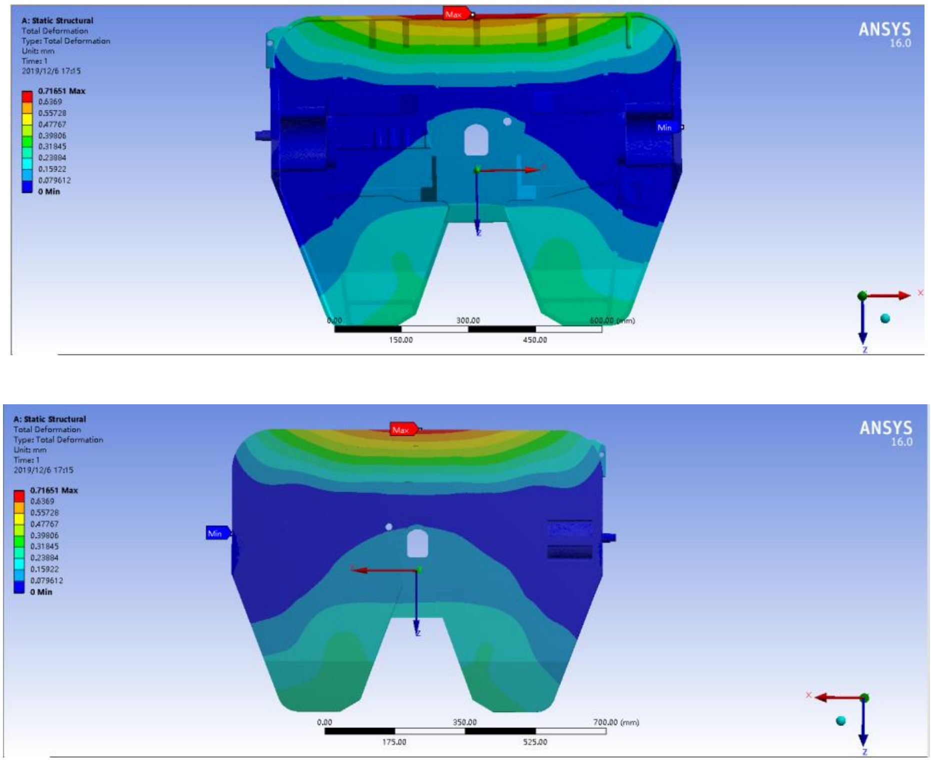


Figure 13. Displacement cloud diagram under static load

From the analysis results of the displacement cloud diagram, the above hypothesis "large load displacement is carried out at the front end of the saddle panel" is also demonstrated. The maximum displacement of 0.71mm appears at the front edge of the saddle panel. The ratio of the displacement value to the front end plate required by the design is 0.07%, far less than 0.2%, which conforms to the requirement of "interchangeability of traction seats for road vehicles"

3.3. Integral Static Finite Element Analysis of Tractor Saddle and Saddle Support

The constraint on the saddle body box is only circumferential constraint, which may be inconsistent with the actual working condition. This section mainly verifies the stress-strain situation under the simulated actual working condition, and installs the upper saddle bracket, sleeve buffer, butterfly hole fixing pin and saddle support bottom plate in the model. Load also use in section F = 1.6 ✕ 105 n, also on the mill panel, as shown in figure 14:

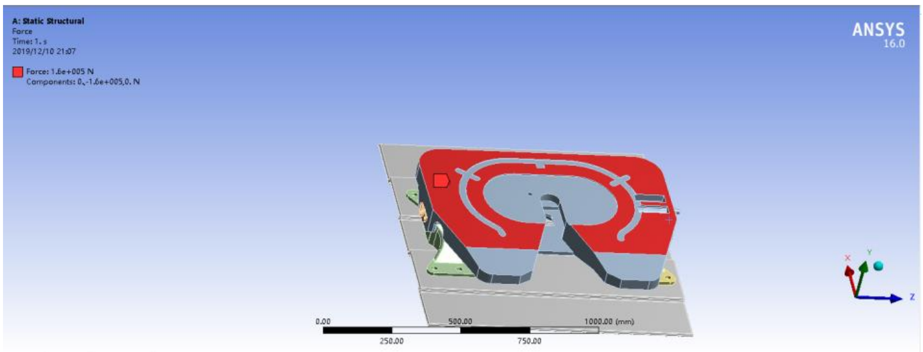


Figure 14. Direction and magnitude of load applied

ISSN: 2664-9640

The hexahedral mesh was also used in the grid, and the grid quality was divided into 6174528 nodes and 3793283 grids. The average grid distance was 0.8mm, and the maximum was 1.00mm (the number was 1, as shown in figure 4.11). The grid quality was in line with the expectation. After continuous improvement and optimization, the final grid division is shown in figure 15:

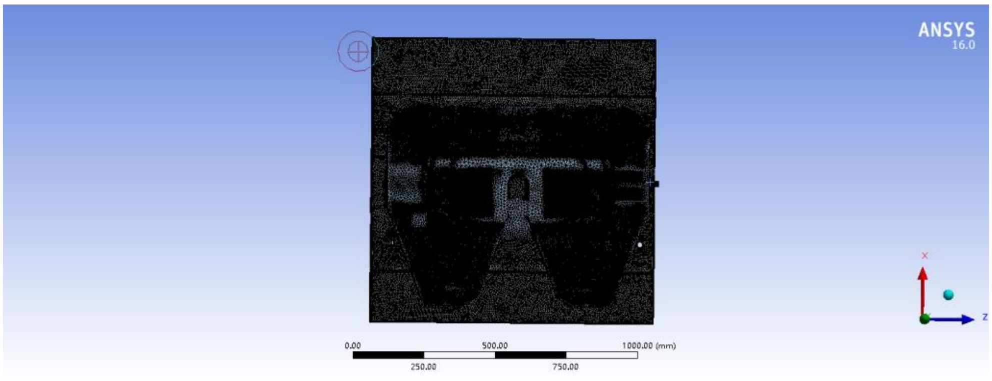


Figure 15. Grid model

After setting the above parameters, the cloud diagram of total stress and displacement is obtained, as shown in figure Figure 16

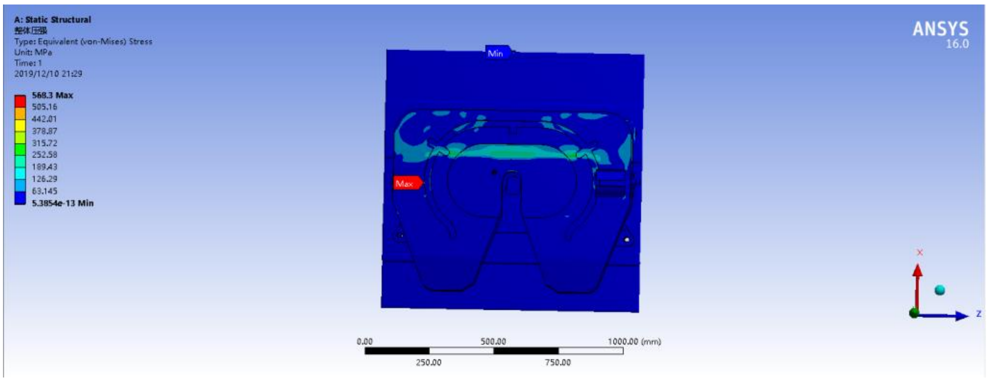


Figure 16. Global stress cloud diagram

The maximum stress is 536.36mpa, which appears on the inner wall of the sleeve buffer, less than the yield strength of high alloy steel 20Cr of 550Mpa.

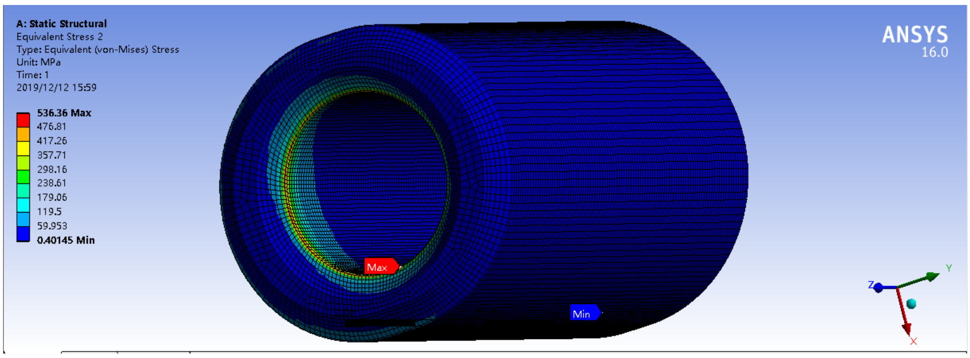


Figure 17. Global stress cloud diagram

ISSN: 2664-9640

4. Conclusion

The analysis results show that it is necessary to pay attention to the design and strengthening of the front panel and the strength design of the sleeve buffer when designing the overall structure of the saddle, which is of certain significance to the overall manufacturer of the saddle.

References

[1] Ju kang. Study on optimal design of traction seat structure of semi-trailer tractor [D].

[2] Chen xiuwu, he ren. Finite element modal analysis of semi-trailer traction saddle body [J]. Machinery Design and Manufacture, 2010(08):10-12.

[3] MATSUMOTO, MASHIDE, ABE. Structural Optimization for Configuration Design of themotorcycle body[J]. Proceedings of the 6th International Pacific Conference On Automotive Engineering, 1991(10):1399-1406.

[4] Bruns T E . Zero density lower bounds in topology optimization[J]. Computer Methods in Applied Mechanics and Engineering, 2006, 196(1-3):566-578.

[5] Biljana D. Stojanović, Skorokhod V V , Maria Vesna Nikolić. Advanced Science and Technology of Sintering[M]. Kluwer Academic/Plenum Publishers, 1999.

[6] Garner C . Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering[J].