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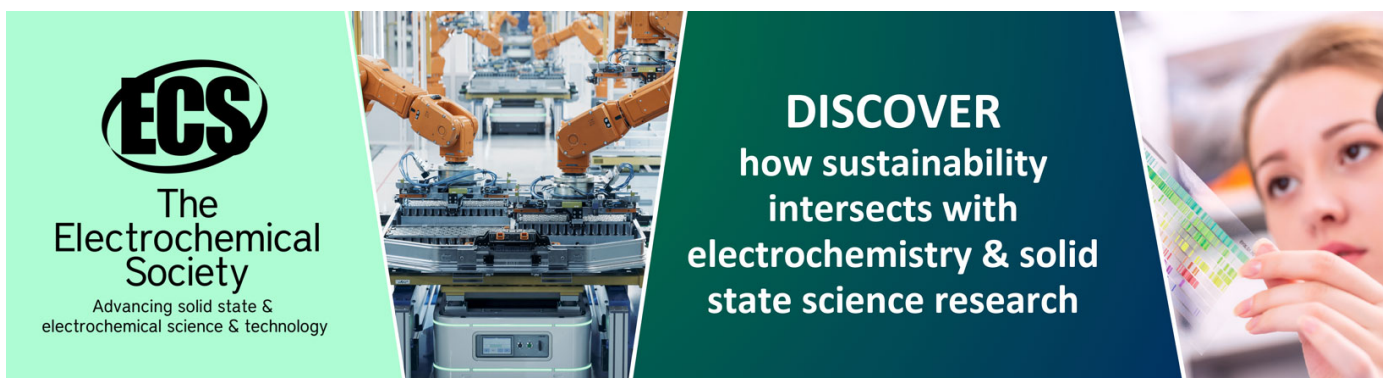
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Research on the Trend of Structural Failures from Vehicle Body Spreader Based on ANSYS Analyses

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Abstract. The operating conditions of the vehicle body spreader have been analyzed in this paper, and all the typical conditions have been applied with the nonlinear finite element analysis of the contact, aiming to ensure the safe utilization of the body spreader of tooling equipment for the production of rail vehicles. The potentially risky component locations are predicted and the weak spots are discovered on the basis of the analysis results of the static strength. The anticipation of the component failure trends shows a guiding role in the failure prediction in actual production and facilitates accident prevention.

1. Introduction

Vehicle body spreader is the process and construction installation equipment of Changchun Railway Vehicle Co., Ltd., and this equipment is used for hoisting the vehicle body. The vehicle body spreader is usually used by pairs, two overhead travelling cranes are used to hoist the construction installation equipment and vehicle body^[1]. Conduct finite element analyses on the vehicle body spreader in order to guarantee the equipment to be safe, scientific and rational. Make prejudgment on the trend of part failures through simulating the static strength and rigidity calculations under multiple working loads^[2], to find out the weak points, and therefore to propose bases to maintenance and to prevent from accidents.

2. Contact Nonlinear Finite Element Analysis Technology

ANSYS finite element software is a multi-purpose finite element calculation program, which could be used for seeking solutions to issues as structures, fluid, electric, electromagnetic field and collisions, etc. ANSYS supports three contact modes: point-point, point-surface and surface-surface, and the contact unit used for each contact mode is applicable for a certain issues^[3]. In order to create the models for contact issues, first of all, it must be realized that which parts in the model might contact each other, and the corresponding component of the model shall be a node if one of the two in mutual contact is a point. The corresponding component of the model shall be an element if one of the two in mutual contact is a surface^[4]. For example, as for the beam element, shell element or solid element, the finite element will recognize the possible contact pairs by means of the designated contact elements.

3. Establishment of Vehicle Body Spreader Finite Element Model

PRO/E 3D mapping software is adopted for 3D modeling of the vehicle body spreader, and HyperMesh v10.0 is used for finite element modeling of the equipment, and the large general finite element analysis software ANSYS is used for static strength analysis of the vehicle body spreader. Perform 3D modeling on the vehicle body spreader according to the drawing data of vehicle body



spreader and the relationship drawings between parts. The 3D model of vehicle body spreader is as indicated by Fig. 1.

Then guide the 3D model into HyperMesh for finite element meshing, and establish the finite element model. All the structures contributing to overall rigidity and partial strength of the vehicle body spreader framework shall be considered. In order to achieve the accuracy of calculations, the finite element model of vehicle body spreader equipment mainly consists of hex solid elements^[5]. The finite element model of the vehicle body spreader is as indicated by Fig. 2.

The defining of contact pairs shall be completed after completing the finite element modeling for all parts. There are two selecting methods among the selections of surface-surface contact pairs, one is selecting solid-to-solid; the other is producing two shells on the surfaces of two contact bodies, and defining the contact relationship for the two shell element surfaces. As for the parts of the equipment are large, many calculations will be increased if the solid contact is selected, so defining the contact relationship for the surface shell elements is selected is more rational for calculations, in order to facilitate calculations. The contact surface defined is as indicated by Fig. 3.

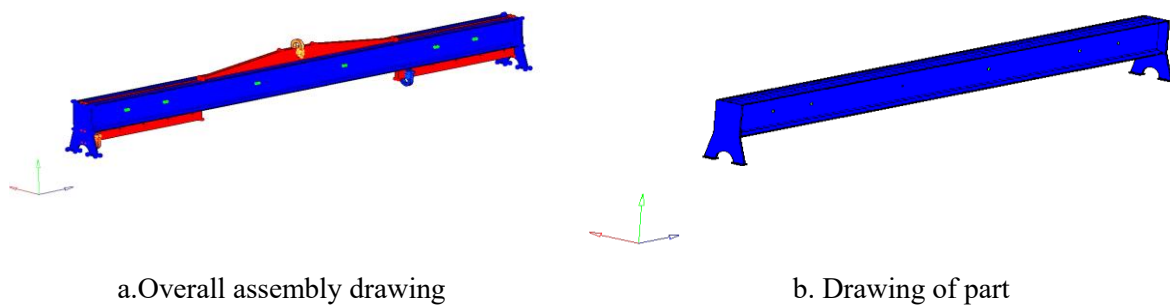


Fig. 1 3D Model of Vehicle Body Spreader

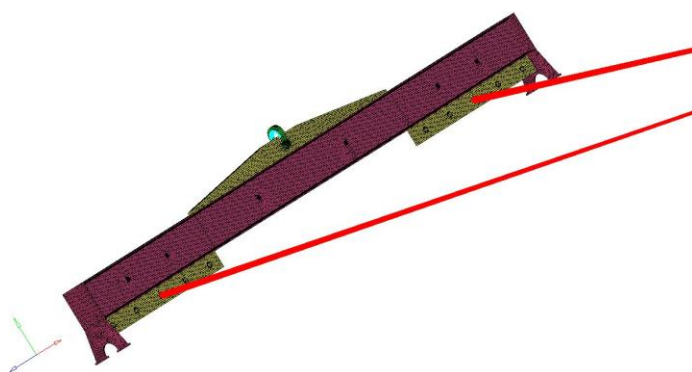


Fig. 2 Overall view to finite element model of the vehicle body spreader

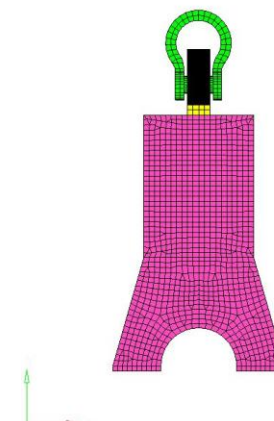


Fig. 3 Diagram of the Contact Surface Defined

4. Loading Conditions and Boundary Conditions

The working conditions for calculations could be classified into 12 according to the working spaces in actual use and according to different working spaces and the loading conditions, and they are respectively the outside, middle and inside general loads and overloading conditions of the simulated frocks and working pieces in the process of operation, the outside, middle and inside eccentric overloading conditions and the overloading conditions with outside high-low, middle high-low and inside high-low. Refer to Table 1 for details of the loading conditions and boundary conditions^[6].

Table 1. Detailed Table for Partial Loading Conditions of Vehicle Body Spreader

No.	Loading Conditions	Marks and Explanations	Loading Values	Load Applying Positions
1	External rated loading condition	FY Each vehicle body spreader	12t	Center of Vehicle Body
2	Middle rated loading condition	FY Each vehicle body spreader	12t	Center of Vehicle Body
3	Internal rated loading condition	FY Each vehicle body spreader	12t	Center of Working Piece
4	External eccentric overloading condition	FY Each vehicle body spreader	12t	Center of Vehicle Body

5. Calculation Results of Static Strength

Footnotes should be avoided whenever possible. If required they should be used only for brief notes that do not fit conveniently into the text.

By means of the ANSYS post-processing treatment function, the calculation results of each working condition could be read, hence, the cloud charts for strains and stresses of various working conditions could be obtained, and the position of secondary maximum stress point could be sought through deducting the maximum stress point and its stress value could be displayed^[7]. 5 stress points are selected in turn in order to find the positions with possible hazards as much as possible.

External Rated Loading Conditions

Under function from the external rated loading conditions, the cloud charts of strain and Von. Mises stress for the vehicle body spreader is as indicated by Fig. 5. The maximum Von. Mises stress of the vehicle body spreader is 134MPa, which occurs at the position of the upper lifting hook shaft; the secondary maximum Von. Mises stress is 84MPa, which occurs at the position of the connecting shaft between the most outside mounting plate and transom; the third maximum Von. Mises stress is 82MPa, which occurs at the position of the most outside lifting hoop hole; the fourth maximum Von. Mises stress is 81MPa, which occurs at the position of the connecting shaft between the middle mounting plate and the transom; the fifth maximum Von. Mises stress is 33MPa, which occurs at the position of the second outside lifting loop hole.

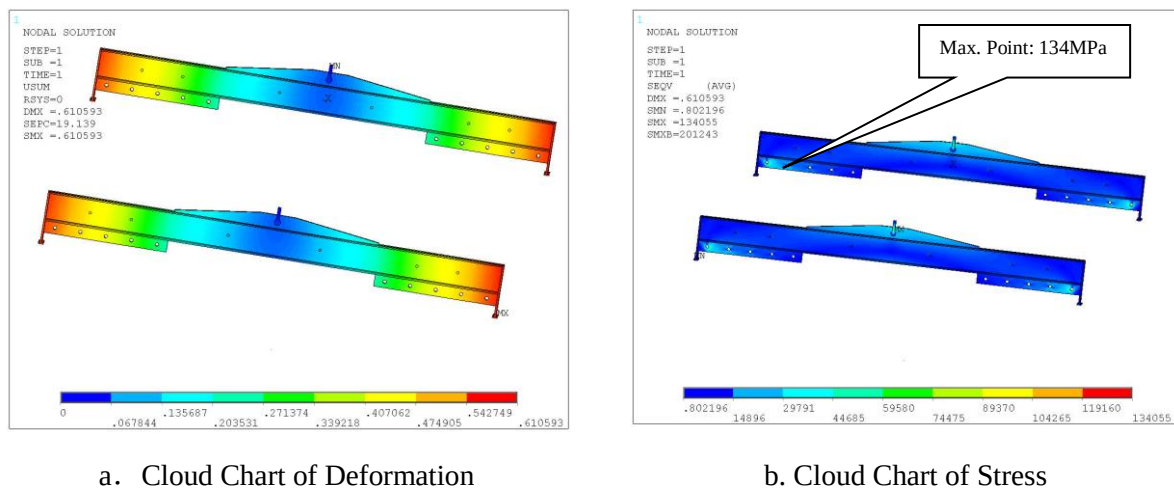


Fig. 4 Cloud Charts for Deformation and Stress of Vehicle Body Spreader under the External Rated Loading Conditions

Middle Rated Loading Conditions

Under function from the middle rated loading conditions, the cloud charts of strain and Von. Mises stress for the vehicle body spreader is as indicated by Fig. 6. The maximum Von.Mises stress of the vehicle body spreader is 136MPa, which occurs at the position of the upper lifting ring shaft; the secondary maximum Von.Mises stress is 52MPa, which occurs at the position of the middle lifting ring hole; the third maximum Von. Mises stress is 51MPa, which occurs at the position of the connecting shaft between the most outside mounting plate and the transom; the fourth maximum Von. Mises stress is 19MPa, which occurs at the position of the inside second lifting ring hole; the fifth maximum Von. Mises stress is 13MPa, which occurs at the position of the lifting ring mounting plate's corner.

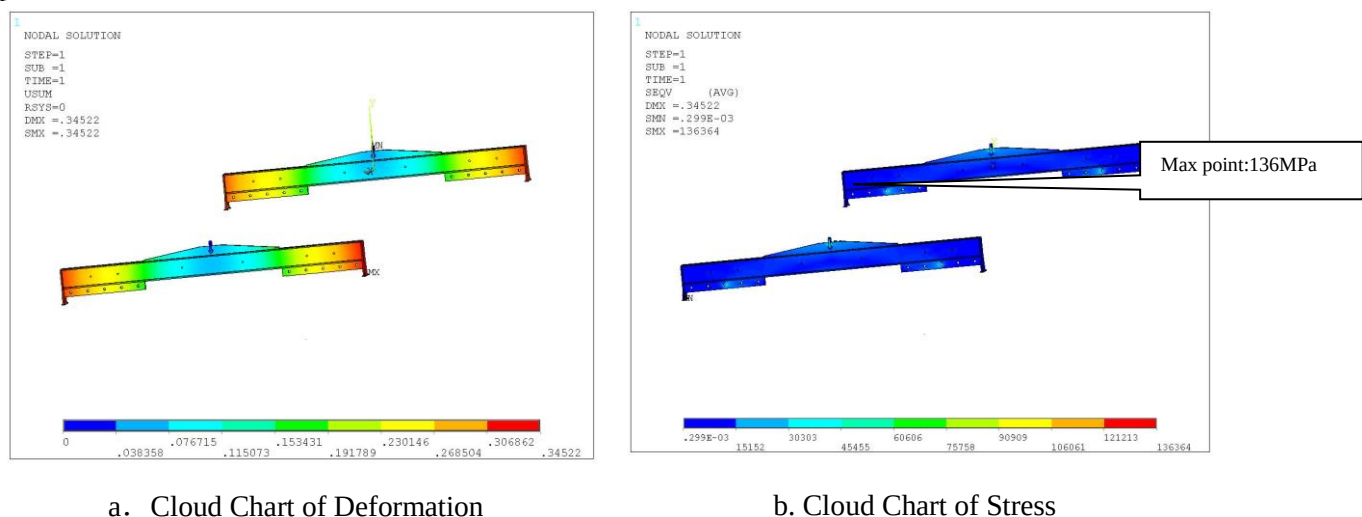


Fig. 5 Cloud Charts for Deformation and Stress of Vehicle Body Spreader under the Middle Rated Loading Conditions

Analyses on Calculation Results

The summary of calculation results for static strength of vehicle body spreader is as indicated by Table 2.

Table 2 Summary of Calculation Results for Nonlinear Static Strength of Vehicle Body Spreader

Working Conditions for Calculations	Maximum Deformation (mm)	Von. Mises Stress (MPa)				
		Maximum Stress	Secondary Maximum Stress 2	Secondary Maximum Stress 3	Secondary Maximum Stress 4	Secondary Maximum Stress 5
Condition 1	0.610	134	84	82	81	33
Condition 2	0.676	138	93	86	82	32
Condition 3	0.345	136	52	51	19	13
Condition 4	0.413	163	62	53	23	15
Condition 5	0.194	116	89	78	77	28
Condition 6	0.232	139	138	79	77	34

As indicated by the results of Table 2, working condition 10 is the most hazardous condition, and its deformations and stresses from various parts are the maximum values of the various working conditions, and this working condition shall be avoided as much as possible in use of the equipment.

The maximum stress of the equipment is located at the contact position between the pin hole and the lifting hook hinge pin, so the surfaces of the pin hole and lifting hook hinge pin shall be critically monitored. Large stresses occur at the welding position between the lifting bushing and the mounting plate, and 100%UT flaw detection treatment shall be conducted before ex-factory.

The major force bearing points occur at the welding positions between the primary mounting plate and the end of U-steel rib plate. Considering from the comprehensive perspective of strain and stress, the pin hole and lifting hook hinge pin are the trend parts for equipment failures and damages; secondly is the welding position between the lifting bushing and the mounting plate.

As indicated by the analysis cloud charts of strain and stress, evidently there is high stress and deformation existing at the external side of the welding position between the U-steel rib plate and the girder rib plate, and shall be considered as the critical object for maintenance.

Refer to Table 3 for summary of the critical monitoring parts for vehicle body spreader.

Table 3 Summary of Critical Monitoring Parts for Vehicle Body Spreader

No.	Critical Monitoring Parts
1	The position of hoisting ring shaft
2	The hoisting ring position
3	The position of shaft connecting the mounting plate and transom
4	The position of hoisting ring hole
5	The position of corner to the hoisting ring mounting plate

6. Conclusions

In order to guarantee the vehicle body spreader to be safe, scientific and rational, the application working conditions for equipment are selected in the paper, contact nonlinear finite element analyses are conducted on various typical working conditions. It's innovatively proposed in the paper that obtaining the positions of the parts might arise with hazards and the contact positions between the pin hole and lifting hook hinge pin through analyzing the results of static strength, and it's the same with the situation of the actual failures. Make prejudgment on the trend of part failure through finding out the weak points. It will guide the prejudgment of failures in actual production and will prevent from accidents. Meanwhile, it will make preparations for the establishing of equipment reliability analysis database in the next step through making prejudgment on the trend of part failures from the equipment.

7. References

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