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The Finite Element Analysis and The Optimization Design of The Yj3128-type Dump Truck's Sub-Frames Based on ANSYS

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Abstract

The article mainly studies the YJ3128-type dump truck's sub-frames, for the fatigue crack occurred in the Sub-frame witch has worked in bad condition for 3 to 5 months, the truck's working conditions and the load features are researched, and ANSYS is used to analyze the stress of the sub-frame. According the deferent stress, the reason of the fatigue cracks' occurring is researched too. At last an improvement and optimization to the structures of the frame is provided. For the stress of YJ3128-type dump truck there is no improved research methods and theoretical support, so the analysis in this paper and the proposed improvement scheme has important reference value.

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Keywords: dump truck, sub-frame, finite element analysis, fatigue crack

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0 Introduction

As the state's infrastructure investment increased year by year, the demand for heavy-duty trucks are also multiplying, China's annual demand of heavy-duty trucks is 95 million or more, and its annual growth rate is 15% or 20%. YJ3128-type dump truck is a Transport vehicles designed and manufactured by Inner Mongolia First Machinery Group Corporation and China North Mercedes-Benz Co., Ltd. It is formed by the main-frame, sub-frame, Cab, cargo box, the hydraulic lifting mechanism, engine, and gears. The sub-frame connected the main frame and the container, and increased strength and stiffness of the main frame, and lead to the main frame 's distributed load force. Therefore, the designing of the sub-frame has the important influence to the main frame's quality and service life. YJ3128-type dump truck's sub-frame is researched by the Co. itself, but after been used for 3-5 months, there will be cracking at the right side of the square beams and the turning point of the left stringer.

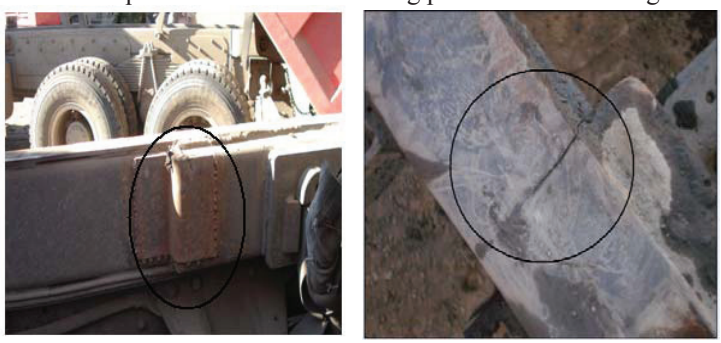

Figure 1 the fatigue crack of the sub-frame

1 The FEM model of the sub-frame

1.1 The structure of the sub-frame

The YJ3128-type dump truck's frame is formed by the main-frame and the sub one, and they are all edge beam type. The vertical beam of the sub-frame is right up the main-frames', and they are connected by the U-bolts. The sub-frame of the truck is developed by the Co., and it's length is 4.7m, forth-width is 0.901m, and the back-width is 0.761m. The 8mm thick V-beam is trough, all its section is the same. There is a trough auxiliary beam flipping In it. There are six beams in the sub-frame, that are a cylindrical beam at the back of it, a square beam in the middle, and four trough beams, Which are showed in figure 2.

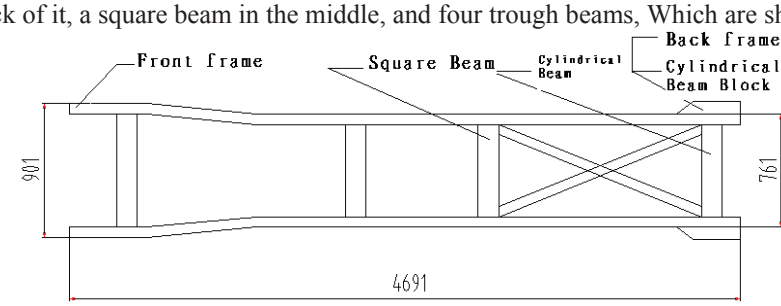

Figure 2 structure of the sub-frame

1.2 Material properties of the sub-frame

The sub-frame material is 16 MnL, the physical properties are: modulus E=210GPa, Poisson ratioμ=0.3, and density ρ=7.8X10-3g / mm3 ; its mechanical properties are: minimum yield strength 345MPa, minimum tensile strength 510MPa, and max tensile strength 610MPa. For the poor working environments, 1.2 is taken to be the safety factor, and the material allowable stress can be inferred to be 287.5MPa. The Pro / E geometric model is imported into the ANSYS for meshing, and the grid size is set to 30 according to Vice-frame's size and analysis precision.

1.3 The load case's size and analysis

The YJ3128-type dump truck is the transport vehicle using in the field operation place such as mining etc., and Figure 3 shows the actual situation. The road is uneven, and there are many big stone on it. This will result in vehicles' one or more tires driving up and down. That is the main cause of the sub-frames' fatigue failure. So the lifting height of the frame is set for 20mm and 50mm, and the Analysis of bending moment and torque are conducted[1][2].

Figure 3 the conditions of the mining road

The load of the sub-frame is shown in the table 1.

Table 1 the load and the force point of the frame

Name	Weight （kg）	Distance between focus to front axle （mm）	Name	Weight （kg）	Distance between focus to front axle （mm）
Assembly of front shock absorber	200	21	Assembly of middle shock absorber	1100	3800
Assembly of front brake	720	0	Assembly of rear brake	1100	5250
Assembly of engine	1200	-200	Assembly of rear suspension	350	4525
Water tank	110	-1000	Oil tank	350	3000

Assembly of cab	2800	-40	Battery	180	1700
Lift cylinder	150	4400	Spare tire	250	1200
load	16000	4000			

2 The finite element static analysis of the sub-frame

2.1 The up-rising of tire is 20mm

As is shown in figure 4, in this case, there were three relatively large stress: firstly, the maximum Von-Mises stress occurs in the final end of frame, it is 331MPa, exceeding the allowable stress of the material. So cracks would appear, and especially it may break at the welding place. Secondly, the stress is about 184MPa, at the right side of the square beams which is near the elevated rear wheel. Thirdly, the stress is about 184MPa, at the turning point of the left stringer. These two stress values are less than the allowable stress[4].

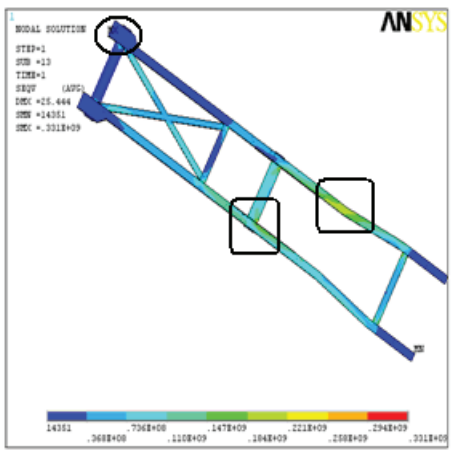

Figure 4 the equivalent stress contours for 20mm

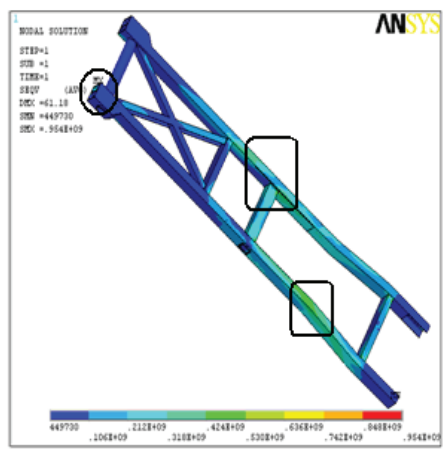

Figure 5 the equivalent stress contours for 50mm

2.2 The up-rising of tire is 50mm

As is shown in figure 5, in this case, there were three relatively large stress: firstly, the maximum Von-Mises stress occurs in the final end of frame, it is 954MPa, exceeding the allowable tensile strength of the material. The cause shall be the frames' irrational structures. Secondly, the stress is about 424MPa, at the right side of the square beams which is near the elevated rear wheel, and the value is also excessive. Thirdly, the stress is about 530MPa, at the turning point of the left stringer. There are also prone to be crack and even break, especially in the welds, the welding is prone to be open, leading to frame's failure.

2.3 Stress analysis

Based on the above results of the sub-frames' analysis, under the joint load, the stress concentration is the greatest at the right side of the square beams and the turning point of the left stringer, and that is the main cause of the frames' fatigue failure. By analyzing, the following conclusions are drawn: The number of the beams the in front of the frames is small, and the one of the beams at end of the frames is large. The

large torsional stiffness causes the uncoordinated deformation. And the stress concentration appeared in the middle frame, and the two key points obtained by the above analysis are just in the neighborhood. They impede the generation of deformation, so the stress concentration deteriorate further. In short, the above mainly due to the frames' lack of torsional.

3 The sub-frames'structural improvements and finite element analysis

3.1 The improved structure of sub-frames

For the main reason of the crack is the lack of the sub-frame's torsional stiffness, a beam is added to the front of the sub-frame, as is shown in figure 6. And the upper surface of the block slope on both sides of the circular beam is turned into inclined plane, then it and the upper surface of the longitudinal are not in the same plane[5].

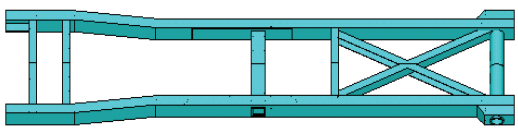

Figure 6 the improved sub-frame

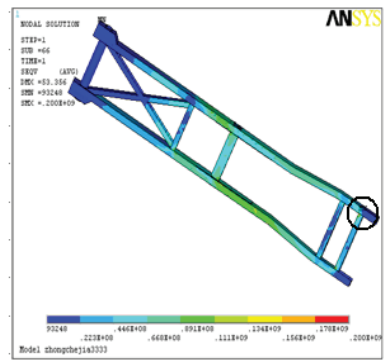

Figure 6 the equivalent stress contours for improved one

3.2 The finite element static analysis of the improved frame

For the frame is damaged in the condition that it is raised 50mm, the analyzing results for the improved frame working in this condition are provided, as is shown in figure 7. Then the max Von-Mises stress is 200MPa, which is under the allowable stress of the material, and it occurs at the front beams. The stress at the right side of the square beams and the turning point of the left stringer is also reduced greatly, and it is only 50% of allowable stress. Therefore, there is no big turning transform in the improved frames, and the torsional stiffness is enhanced. No excessive stress concentration exists, and the bearing capacity is greatly improved. Thus it meet the design and use requirements.

The above analysis results show that the proposed changes to the program is reasonable. In order to verify the reliability of the actual for the improved frame, the method is feedback to the Co., and the method is accepted.

4 Conclusions

Heavy trucks is commonly used transport vehicles in the site, mining and other places, their working conditions are bad, and dynamic load is great. For the frame is their important load component, the quality of the frame is directly related to the performance of heavy trucks. In this article, the sub-frame is analyzed by ANSYS, and the reason for the cracking of the frame is found, and the improving method is

shown for the Company. A theoretical basis is provided for the improvement of the frames' designing, and an important reference is provided to improve the truck frame's design methods.

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