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Structure Design and Finite Element Analysis of a Connection Assembly Program

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Abstract: The new connection assembly program contains four cone-shapes of fixed welders and four bolts. It is used for connecting the cover assembly of a Down-The-Hole (DTH) drill rig and its chassis. The design feasibility and reliability are evaluated according to the mechanical calculation and finite element method.

Key words: cone-shape of fixed welder; computer software; mechanical calculation; strain; finite element method

1 Prologue

The improved design is already used in the products of our corporations like the crawler hydraulic DTH drill SD L6. It is implemented based on the relationship between intervene analysis and efficient space about assembling so as to meet the requirement of optimized design and working reliability. There is a new part called cone-shape of fixed welder.

2 Overview

The structure consists of four bolts and four cone-shape of fixed welders. A group of two bolts is installed in the middle bottom of the cover along the side. The shape of the cone-shape of fixed welder is show in Figure 1. 1. Its dimension is $72\times52\times84.2$, and thickness is 5. The area of thrust surface is 72×50 and 52×50. The part is rigid connected with the chassis. Four parts are located on the four corners of the quadrangle of the chassis and connect with the cover assembly.

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3 Mechanical calculation and finite element analysis

Use Pro-e to measure the quality of the model cone-shape of fixed welder. Its mass is 638. 00 kg, see Figure 1. So its weight is $G=6\ 252.40$ N.

In the ideal operation condition, the maximum longitudinal loading stress is on the bolts. Because in the maximum condition, with the downward pulling of the cover assembly gravity, the upward support force of the chassis is zero, as the effect of inertia. In order to reach the working reliability, the axial force of bolts is equal to the weight of the cover assembly. Now increase and simplify the axial force of bolts: $F_N=6\ 400$ N.

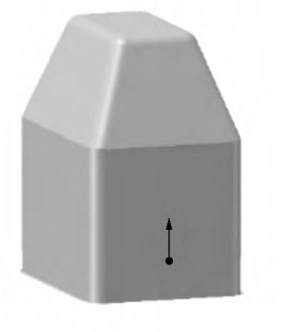

Figure 1 Model structure diagram

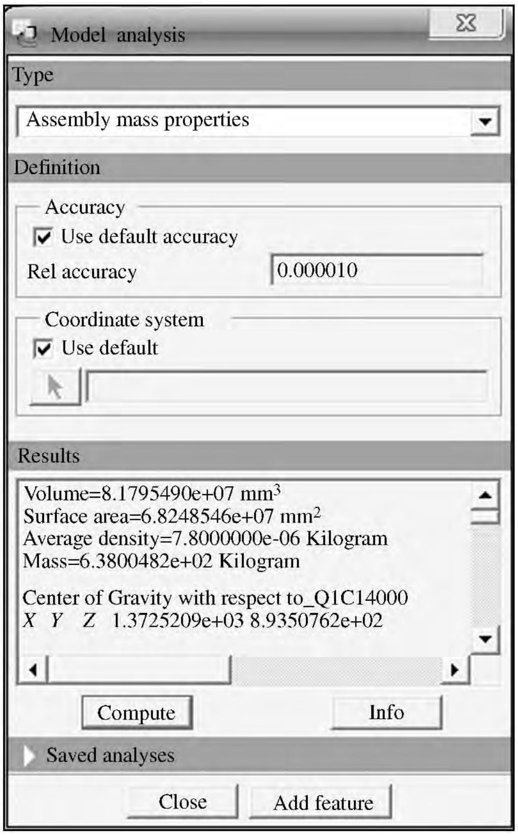

Figure 2 Model analysis results diagram

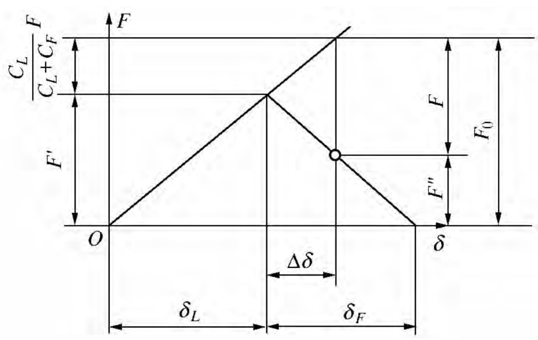

Figure 3 Chart of mechanical deformation

During tramming and drilling of DTH drill, the bolts are stressed on the pretightening and axial fluctuating load. We assume each group of bolt is stressed on the equal force. This shows that the axial force which stress on a single group of bolts is: $F=F_N/4$. According to the chart on mechanical deformation between bolt and connection part (see Figure 3), the max. axial force of the group of bolts is:

$$F_0 = F'' + F \qquad (1)$$

F'' is residual pretightening force of bolt, check in the table 5-1-62 of the standard handbook of machine design: $F''=(0.6\sim1.0)\ F$, the coefficient is 1.0.

Computational formula of maximum. tensile stress of tightening bolt:

$$\sigma_1 = \frac{1.3\times 4F_0}{\pi d^2}$$

Computational formula of allowable tensile stress:

$$[\sigma_1] = \frac{\sigma_s}{S_s} \qquad (3)$$

σ_s——The yield point of bolt material, check in the table 5-1-61 of the standard handbook of machine design, $\sigma_s=240$; S_s——Security coefficient, check in the table 5-1-64 of the standard handbook of machine design, $S_s=3$.

So, maximum. tensile stress of bolt is: σ_1 = 20.7 MPa, while allowable tensile stress is: $[\sigma_1]$ = 80 MPa. Compare: $\sigma_1<[\sigma_1]$.

Because of the axial fluctuating load of bolt, the computational formula of stress amplitude of bolt is:

$$\sigma_a = \frac{2F}{\pi d^2}\times\frac{C_L}{C_L+C_F} \qquad (4)$$

Where $\frac{C_L}{C_L+C_F}$ is relative stiffness coefficient, check in the table 5-1-62 of the standard handbook of machine design, $\frac{C_L}{C_L+C_F}=0.7$.

Allowable stress amplitude is:

$$[\sigma_a] = \frac{\xi\sigma_{-1t}K_tK_u}{K_\sigma S_a} \qquad (5)$$

Where ξ is size factor, $\xi=0.87$; σ_{-1t} is endurance limit of specimen, $\sigma_{-1t}=120$ MPa; K_t is thread manufacturing press factor, $K_t=1$; K_u is non-uniform stress factor, $K_u=1.6$; K_σ is notch concentration factor, $K_\sigma=3$; S_a is safety factor, $S_a=2.5$.

So, stress amplitude of bolt is: $\sigma_a=3.98$ MPa. While allowable stress amplitude of bolt is: $[\sigma_a]$ = 22.27 MPa. Compare: $\sigma_a<[\sigma_a]$.

The maximum. transverse load of connection part equal to the force overcoming the static friction force. Check in the table 1–1–7 of the standard handbook of machine design, the static frictional coefficient $\mu = 0.15$. The frictional force $f = \mu F_N$, so static friction force $f = 960$ N. In the ideal working condition, every cone-shape of the fixed welder is pressed to the same transverse load. The transverse load $F_s' = 160$ N. So the cutting stress of one bolt $F_s = 80$ N. The shear stress is

$$\tau_1 = \frac{4F_s}{m\pi d_1^2} \tag{6}$$

Where m is the shearing number of fitting bolt, $m = 1$; d_1 is shearing diameter of fitting bolt.

The allowable shear stress is

$$[\tau_1] = \frac{\sigma_s}{3.5 \sim 5} \tag{7}$$

The maximum. shear stress of bolt is $\tau_1 = 0.40$ MPa, while allowable shear stress is $\tau_p = 48$ MPa. The 4× M16 bolts already reach the useful requirement on the basis of the above calculate.

Using SolidWorks to analyse the cone-shape of the fixed welder, according to the ideal connection situation, it is pressed by the vertical transverse load and uniform tension. The material of the cone-shape of the fixed welder is general carbon steel, and its density is 7 800 kg/m^2. Poisson's ratio is 0.28. Yield strength is 220.59 MPa. Modulusofelasticity is 2.1×10^{11} N/m^2. Shearing modulus is 7.9×10^{10} N/m^2. Tensile strength is 399.8 MPa. The fixture is fixed geometry. Loading: with only force on the X or Y axis direction, its value is 160 N. With the sum force on the X and Y axis direction and the angle is 45°, its value is 113.15 N. The different static stress distribute graph see Figure 4 static stress distribution diagram. Figure 4a) is X axis direction, and its max. stress is 2.29 MPa. Figure 4b) is Y axis direction, and its max. stress is 2.10 MPa. Figure 4c) is X and Y axis direction, and its max. stress is 1.61 MPa. While the max. stress are all less than the yield stress 220.59 MPa.

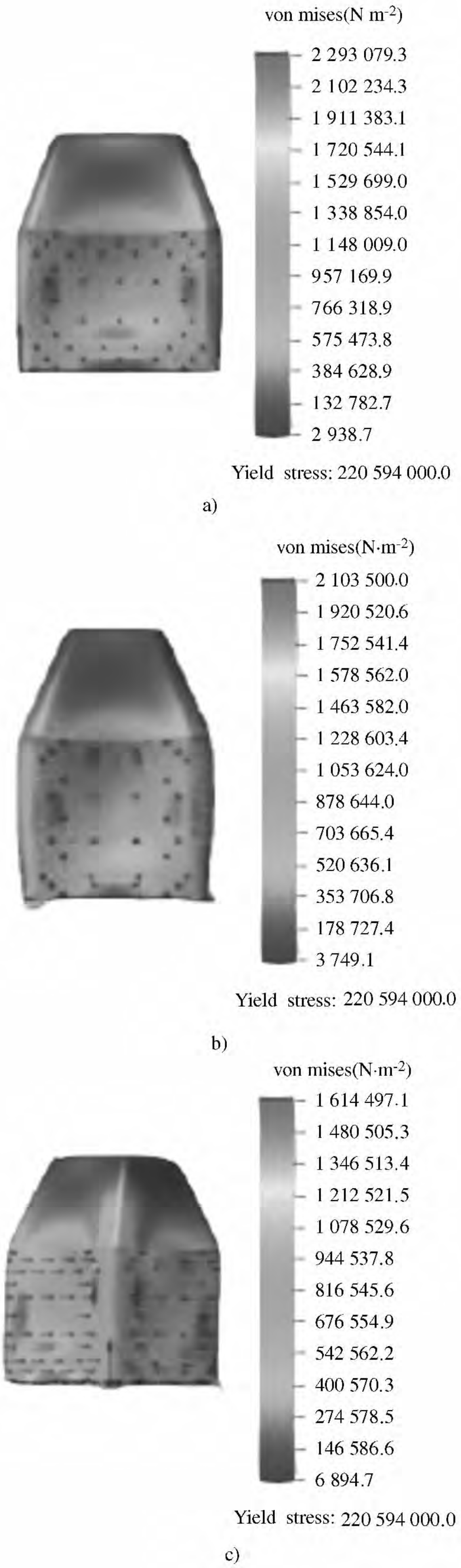

Figure 4 Static stress analysis diagram

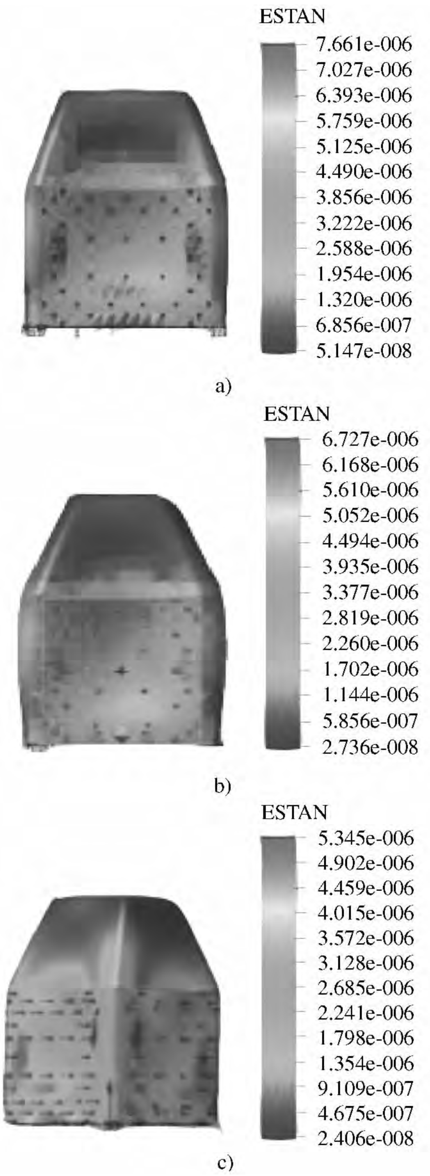

Figure 5 Static strain analysis diagram

Figure 5 is static strain analysis of cone-shape of fixed welder in different direction, *X* or *Y* axis or *X* and *Y* axis. Figure 5a) is *X* axis direction, and its max. strain is about 7.66×10^{-6} mm. Figure 5b) is *Y* axis direction, and its max. strain is about 6.72×10^{-6} mm. Figure 5c) is *X* and *Y* axis direction, and its max. strain is about 5.85×10^{-6} mm. So, its strain is not useful about security of actual procedure.

4 Conclusions

We calculate axial tensile stress, shear stress and stress amplitude of bolts. Analyse stress and strain of the cone-shape of fixed welder. We know this improved design reach to the requirement of theoretical design. In fact, our corporations using the cone-shape of fixed welder drill well on the outdoor mine, and have no problem about connected lose efficacy like connected deformation and rupture.

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Brief Biographies

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