Finite Element Analysis of Boring Machine

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Abstract

The key parts of the whole hydraulic drilling rig designed in this paper include: main shaft, supporting plate, chuck plate, oil distribution sleeve, etc. In the working process, the force is large, the wear is severe, and the transfer of force between components is complex, so it is difficult to calculate the force by using the traditional algorithm.Therefore, based on ANSYS Workbench, this paper conducts numerical simulation of the key components of the above all-hydraulic drilling rig to complete its stress, strain analysis and optimization design.

Keywords

Rig; finite element; optimization; hydraulic.

1. Establishment of Relevant Models

In this paper, the whole hydraulic drilling rig contains a large number of assemblies and parts. If the finite element analysis of all assemblies or parts is carried out, the article will be lengthy. Therefore, the finite element analysis is only carried out in this paper for the main shaft, supporting plate, chuck plate and oil distribution sleeve with large stress and wear during the working process. First of all, the author uses SolidWorks to complete the 3d modeling and assembly of the above components. At the same time, in order to import the related analysis into workbench, the author saves it as the SAT file format to ensure the data interaction between the two CAD software. In order to facilitate the calculation and improve the calculation speed, the author also simplified the model of the support plate and the model equipped with a sleeve, and omitted some threaded holes that had little impact on the calculation results[1], so as to improve the speed of finite element analysis and the precision of grid division, and further improve the accuracy of the calculation results.

2. Model Material Definition and Grid Division

Model is complete, and save to the appropriate file format you can import it into the corresponding mechanical analysis in the workbench, after import after the workbench, still need to open the workbench designmodeler check model is generated or generate complete, if has not generated or generating incomplete, you need to in designmodeler to regenerate the model itself, in the guarantee intact after imported into the workbench model, before the next step of finite element analysis[2].

After the model is generated, the material properties of each component need to be defined.According to the practical production and application, the spindle materials using 40 cr, is a mechanical manufacturing, one of the most widely used steel after tempering treatment have good comprehensive mechanical properties, good low temperature impact toughness and low notch sensitivity, used in the manufacture of high hardness and wear resistance and no impact to the surface of the parts, such as gear, sleeve, shaft, spindle, spindle, pin, connecting rod, crankshaft, screw, nut, inlet valve, etc.In addition, this steel is also suitable for manufacturing various transmission parts for carbon and nitrogen eutectic treatment, such as gears and shafts with large diameter and good toughness at low temperature .Its material properties are: E=200~211GPa, =0.269.

The material of the supporting plate is zg270-500, which is a kind of medium carbon cast steel. It has certain toughness and plasticity, high strength and hardness[3], good cutting ability, and is widely used in making flywheel, vehicle coupler, hydraulic cylinder, rack, steam hammer cylinder, bearing seat, connecting rod, box body and crank .

The material property is: E=202GPa, the limit value is 0.34.The model diagram of the chuck is shown in the figure. It consists of three parts: shaft, slip and glue tube. When working, the hydraulic oil enters the chuck body from the oil hole on the main shaft and ACTS on the glue tube. At the same time, the material defined by the slip is 20CrMnTi, which is a kind of cementing steel with good performance and high hardenability, especially with high low temperature impact toughness under the condition of ensuring the hardenability. Main USES: for axle, piston parts and automotive, aircraft special parts. The material property is: E=207GPa, which can be used as material. The rubber tube is made of composite material rubber, and the composite material itself is a high molecular compound, which belongs to the elastomer. Its poisson ratio is close to 0.5 and generally varies from 0.45 to 0.4999.Because the elastic modulus of rubber matrix material is small, the rubber material can be simplified and considered uniformly continuous and isotropic. At the same time, due to the fact that the rubber parts have little constraint on the rubber parts in the actual working process, the deformation amount of the rubber parts is also relatively small, so the large deformation problem can be ignored, which can be approximately regarded as a linear problem to be solved[4].

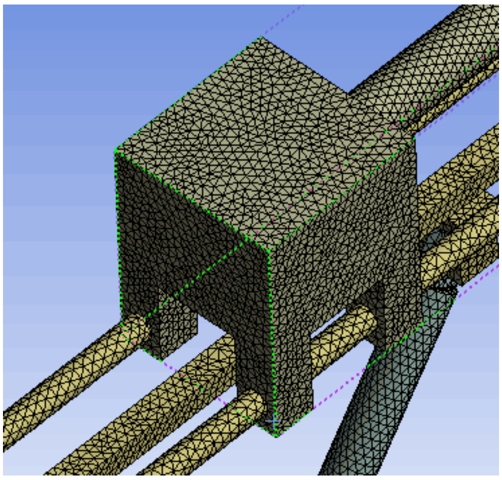

Fig 1. Spindle grid

When dividing the grid unit, the tetrahedron grid is adopted for all the above parts, and the size of the grid unit is set to 10mm. It can be seen from the figure that the grid shape of each part is good and the grid distribution is even. For quality inspection at the same time, its biggest grid cell partial slope and a grid cell number as shown in table 1, as can be seen from the table, four parts partial slope is less than 0.6, the biggest cell grid ideal quality, grid cell number is larger, the whole grid density is opposite bigger, to ensure the accuracy of the simulation results.

3. Boundary Conditions Are Set and Loads Are Applied

In the finite element calculation, the setting of boundary conditions has a great influence on the analysis results. Therefore, the setting of boundary conditions must be consistent with the actual working conditions to ensure the correctness of the results.

In the working process of this drill, the feeding and pulling work is mainly carried out. In practical application, the feeding condition accounts for a large proportion. Therefore, this paper only analyzes the feeding condition[5].

The boundary conditions of each part are set as follows:

(1) in the process of feeding, since the power head is installed on the supporting plate of the feeding device by means of bayonet slot connection, it can be seen from its working state that the spindle exerts three directional translational degrees of freedom at its positioning surface, that is, U1=U2=U3=0.

(2) as the bottom surface of the support plate is always closely attached to the guide rail, the guide rail constrains the translational degrees of freedom in the three directions of the lower bottom surface of the support plate, i.e., U1=U2=U3=0.

(3) chuck in the working process of the feed, the slip under reverse force of drilling tools for drilling rig, and at the same time this paper in order to reduce the calculation time, the chuck model simplified, make the spindle and slip into an organic whole, convenient for simulation analysis and calculation, the analysis according to its actual working conditions, the boundary condition constraints is mainly composed of two parts, one is to limit the axial slip degrees of freedom[6], and limits the radial motion of slip along the only twist plate motion card slot, even if the U1 = U3 = 0, 2 it is to limit the end of the rubber tube axial and radial motion, namely the U1 = U2 = U3 = 0.

(4) the oil distribution sleeve is mainly subjected to oil pressure. According to its working state, it is easy to know that the oil distribution sleeve only limits its axial displacement by the core pipe, so the boundary condition U3=0 is applied on the hole wall of the inner coat.

4. Finite Element Analysis of Each Component

According to the above parameter setting, the stress and strain cloud map of each component can be obtained through workbench static analysis and finite element calculation. The stress and strain cloud map of the spindle is shown as follows:

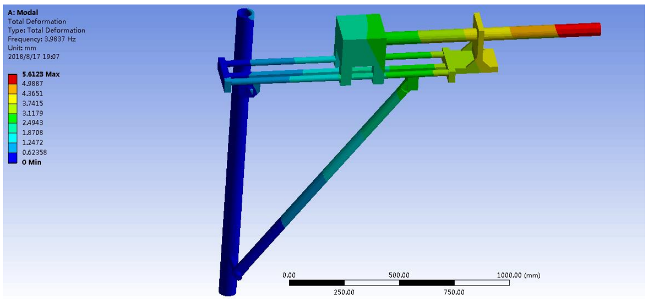

Fig 2. Principal axis deformation cloud map

It can be seen from the deformation cloud map in the figure that the maximum deformation is 0.02 mm. Compared with the actual size of the spindle, the deformation amount is very small and fully meets the requirements of industrial design.According to the stress cloud diagram, the maximum stress is 48MPa, and the yield limit of 40Cr of spindle material is 785MPa, with a safety factor of 16.35 and high safety.

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