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Mechanical Research and Optimization of Wide Blade Drill Pipe Based on ANSYS

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Abstract: In view of the phenomenon of suction drill stuck in the process of protruding soft coal seam drilling, taking horizontal drilling as an example, by analyzing the movement law of drilling powder between wide blade blades during the drilling process of wide blade drill pipe, it is determined that when drilling When the amount of pulverized coal is greater than the discharge capacity of the drill pipe, it is easy to produce a mechanical mechanism of suction-drilling due to a large backlog of pulverized coal. Determine the powder discharge mechanism of the wide blade drill pipe, analyze the pressure loss when the drill pipe discharges the slag, and carry out the mechanical ANSYS simulation of the wide blade drill pipe joint to design and optimize the more reasonable drill pipe structure. The simulation results show that under different stress conditions, the powder discharging effect of the wide blade drill pipe is different, which in turn affects the drilling construction process of the drill pipe. Optimizing the structural parameters of the wide blade can effectively improve the working efficiency of the drill pipe.

Keywords: Dust removal mechanism; slagging; ANSYS simulation; structural parameters.

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1. PREFACE

In the soft and protruding coal seams, fluid slagging is usually the mainstay, and mechanical power slag is supplemented. Fluid slagging power is mainly derived from high pressure gas flow. That is, a high-pressure airflow is injected into the drill rod cavity, and the airflow carries the drill residue cut by the drill bit to be discharged outside the hole. However, due to the unclear understanding of the mechanism and process of the pneumatic slagging, the slag discharge channel is not smooth during drilling, which in turn affects the drilling efficiency and the depth of the hole. Therefore, in order to improve the drilling construction process, the force and pressure loss of the drill pipe during drilling are analyzed under the premise of studying the pressure loss during the airflow and drilling slag transportation, and the ANSYS statics and modal simulation of the drill pipe is carried out. Optimization, providing a better solution for the optimization of wide blade drill pipe in soft coal seam [1-2].

2. MECHANICAL ANALYSIS OF THE MECHANISM OF ROWING OF WIDE BLADE DRILL PIPE

2.1 Analysis of pulverized coal movement.

Wide blade drill pipe during the horizontal drilling process, the bit rotates at high speed to cut the coal from the coal body, and the cut coal powder rotates with the drill pipe. Due to the centrifugal action, the pulverized coal gradually moves toward the pore walls. Subsequently, under the action of gravity, interaction between coal powders, friction between coal powder and blades and coal wall, the coal powder gradually decelerates, no longer rotates with the wide blade drill pipe and produces relative displacement with the wide blade [3-4]. Thereby starting to produce axial velocity. Thus, under the action of the wide blade, the pulverized coal is tumbling at the lower portion of the borehole and moving to the outside at a constant speed until the discharge hole.

Take pulverized coal A as the research object, and make a force diagram of pulverized coal A on the wide blade. As shown in Figure 1.

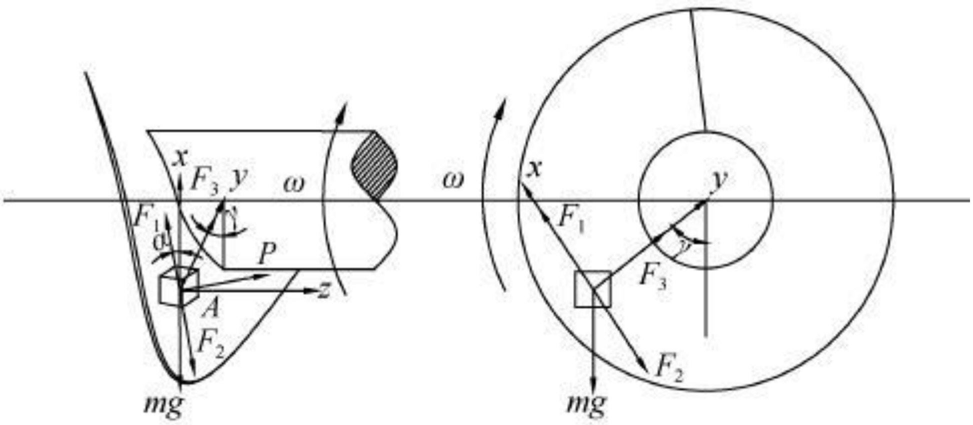

Figure 1. Stress analysis of pulverized coal on wide blade

Due to the uniform movement in the axial direction of the pulverized coal in the outward transport phase, the radial movement is an approximate shifting circular motion, according to Newton's second law:

$$\sum F_X = ma_{切} = m\frac{d^2x}{dt^2} \sum F_y = ma_{向} = m\omega^2 r \sum F_z = 0 \quad (1)$$

Specifically, then:

$$(F_1 - F_2)\cos\alpha - mg\sin\gamma = m\frac{d^2x}{dt^2}$$

$$F_3 - mg\cos\gamma = m\omega^2 r$$

$$P\cos\alpha - (F_1 - F_2)\sin\alpha = 0 \quad (2)$$

Also because $F_1 = Pu_1$ $F_2 = F_3u_2$ $\omega = 2n\pi$; Bringing into the above formula (2), the support force of the wide blade to the coal powder can be obtained as follows:

$P=\frac{mgu_2\cos\alpha\sin\alpha+4\pi^2mn^2ru_2\sin\alpha}{u_1\sin\alpha-\cos\alpha}$; Substituting and finishing can obtain the equation of motion of the wide blade drill pipe:

$$\frac{d^2x}{dt^2}=\frac{gu_2\cos\alpha}{u_1\sin\alpha-\cos\alpha}\left(u_1\cos\alpha\sin\alpha-\sin\alpha\cos\gamma u_1+\cos\gamma\cos\alpha\right)-g\sin\gamma+4\pi^2n^2ru_2\cos\alpha$$

Where P is the support force of the wide blade to the coal powder, N; m is the mass of the coal powder A, kg; g is the acceleration of gravity, m/s2F1 is the frictional force of coal powder parallel to the wide blade, N; F2 is the friction between coal powder and coal wall or other coal powder, N; F3 is the support force of coal powder by coal wall or other coal powder, N; 11 is the friction coefficient of pulverized coal and wide blade; μ2 is the friction coefficient of pulverized coal and coal wall; α is the rising angle of wide blade, (o); γ is the angle between the position of pulverized coal and vertical line, (on) is the speed of the wide blade drill pipe, r / s; R is the radius of the location of the pulverized coal, mm. It can be seen from equation (2) that when the friction component is greater than the gravity component, the pulverized coal moves upward; when the gravity component is greater than the friction component, the pulverized coal moves downward, which can simulate the pulverized coal rolling forward. Movement state [5].

3. MECHANICAL SLAG MECHANICAL ANALYSIS

3.1 Drill pipe mechanics model.

Now a typical wide blade drill pipe is studied. The structural parameters of the drill pipe are: outer diameter D=73.5mm, inner diameter d=63.5 mm, blade thickness b=5mm, blade height h=18 mm, wide blade the blade has a lead of s=96 mm, which is modeled as shown in Fig. 2.

Figure 2. Solid model of wide blade drill pipe

3.2 Drill pipe static analysis.

Static analysis in ANSYS Workbench is one of the most commonly used fields in finite element analysis. It is used to analyze the response of a structure under a fixed load. Static analysis is mainly used to analyze the displacement, stress, strain and other parameters caused by the load (excluding inertia and damping) acting on the structure or component.

Static analysis is performed by the Static Structural module, which includes model import, definition of material properties and assembly types, meshing, addition of loads and constraints, solution and post-processing of results [6].

(1) Model import: Model import is a process of importing a three-dimensional model created by three-dimensional software such as SolidWorks, Pro/E, and the like into ANSYS Workbench. The introduction of the model is the basis of static analysis. We should simplify the model when it is built, and then import it into ANSYS for processing to get accurate and reasonable analysis results.

(2) Material properties and assembly type definition: Material properties need to be re-added in this module, the system will automatically configure properties such as material density, Young's modulus and Poisson's ratio [7-9]. When you import an assembly, the program automatically generates contact pairs between the two entities.

(3) Meshing: ANSYS Workbench provides an automatic meshing solution. The default meshing unit of the system is Solid187 tetrahedral unit, and the system can also define other units according to structural features.

(4) Adding loads and constraints: Workbench contains inertial loads, structural loads and constraints, which need to be defined according to the object. Inertial loads have an effect on the overall system. Structural load refers to the force or moment acting on the structure. A constraint is a constraint that limits the range of motion of a structure [10-13].

3.3 Define grid control and mesh.

According to the characteristics of the 3D geometric model unit, the selection method and the mesh division method, the grid setting and division of the drill pipe are as follows: the thickness of the components on the drill pipe varies between 10 and 20 mm, which is a three-dimensional solid model. The geometric model unit is SOLID92 unit. The calculation accuracy of this unit is relatively high, and the calculation scale is relatively small. It is suitable for the static analysis of the drill pipe. The grid division method uses the meshing method of Hexdominat hexahedron and Tetrahedrons tetrahedron.

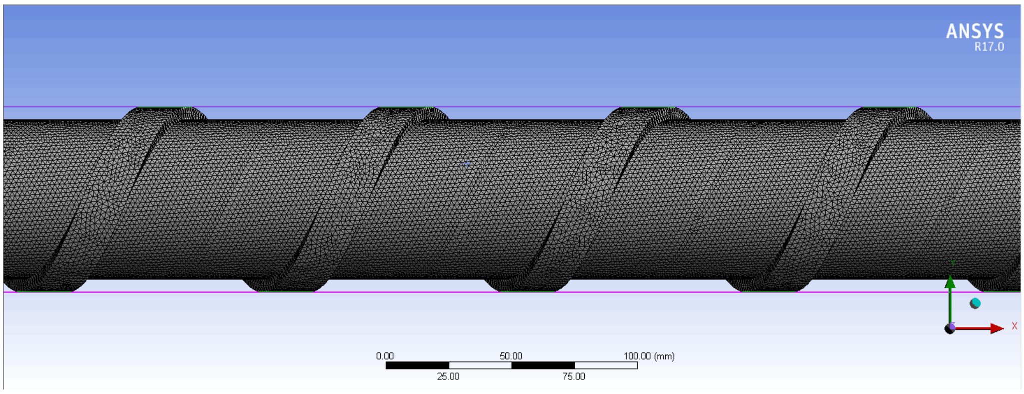

Figure 3. Schematic diagram of grid analysis of finite element analysis of drill pipe model

The results of the drill pipe meshing are shown in Figure 2-3. A total of 25,967 nodes and 11,730 cells are obtained.

3.4 Applying load and boundary conditions to the drill pipe.

Linear static structural analysis is a finite element analysis of a component without considering inertia and damping, and calculates the effect of the component when it is subjected to a fixed load [14]. We refer to the finite element analysis of components under fixed inertia loads or loads that do not change with time. Static analysis is mainly used to analyze those loads that do not contain inertia or damping effects [15-18]. The problem of displacement, strain, and stress changes caused by the assembly.

Add loads and constraints as shown in Figure 4.

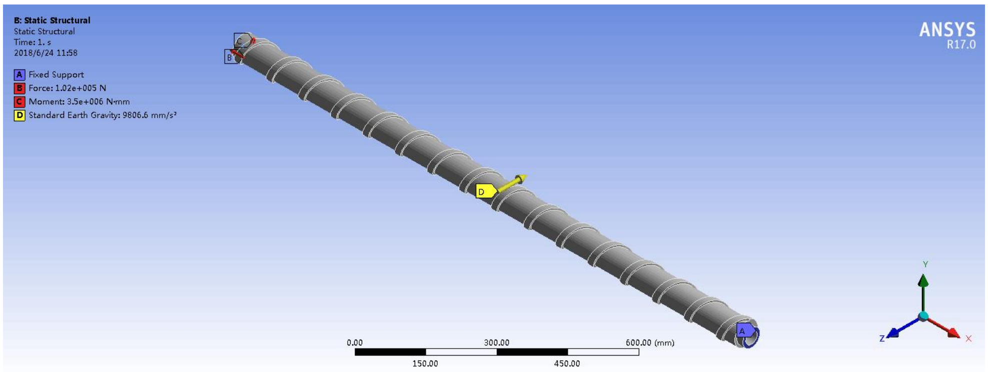

Figure 4. Add load and constraint diagram

4. DRILL PIPE MODAL ANALYSIS

Modal analysis is an analytical method that reflects structural vibrations. It determines the natural frequency, mode shape, and mode factor. Performing modal analysis allows the structural design to avoid resonance or vibration at a specific frequency, which is useful for estimating the control parameters in other dynamic analyses. It is the basis for other dynamic analysis.

The drill pipe is a rotating component. In addition to the design that satisfies the strength and rigidity, in order to avoid the resonance phenomenon in the drilling process affecting the drilling efficiency, it is necessary to study the vibration.

The ANSYS software was used to extract and analyze the low-order mode shape of the drill pipe, and the first six-order mode shape of the drill pipe (Fig. 5) was obtained.

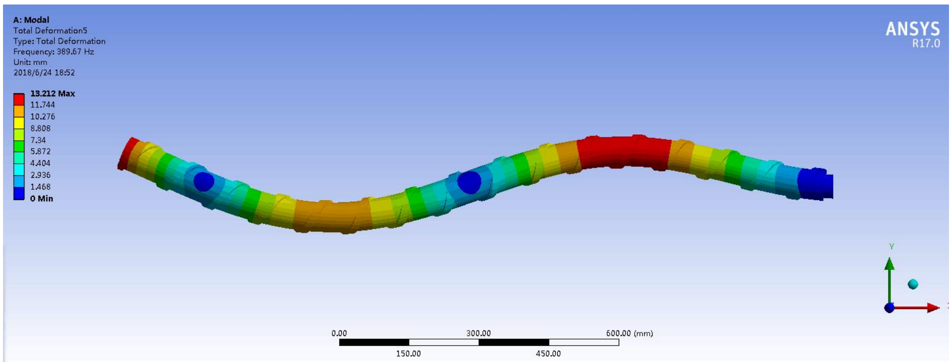

Figure 5. Modal mode

5. SUMMARY

By analyzing the force analysis of the pulverized coal between the blades during the drilling process of the wide blade drill pipe, combined with the mechanical stress of the pulverized coal, the mechanical mechanism of the pulverized coal of the auger is discussed. The phenomenon of suction and card drilling that often occurs during the drilling of soft coal seams is improved to some extent from the amount of coal produced and the ability to discharge coal. In addition, the rationality of the wide blade drill pipe structure is verified by the static simulation and modal simulation of the wide blade.

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