CAD-Based Bit Design for Inner Wall Descaling of Water Injection Pipe

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Abstract. Water pipeline scaling serious by prolonged use, result in a substantial diameter narrowed, reduced water efficiency. In order to solve this problem, analyzes the deposition feature and the drill descaling method, research on drill descaling theory and chip formation process. Choose multi-tooth bit as a foundation. According to the characteristics of processing object, improved the structure and cutting teeth distribution, get a new type of scaling drill. Take the inside wall of injection pipe and scale as research object, established finite element model for static analysis, get stress graph and stress curve, showed the wall stress state in drilling process.

Introduction

Water injection pipe is an important oil production, because the water injection for sewage, water injection pipeline after long time use, scale and grit combination makes wall scaling phenomenon is serious, lead to work diameters, underground water injection pressure drop, water injection efficiency is lower, so you need to remove the water injection pipe regularly use [1] to continue after cleaning the well. Mechanical drilling cleaning is an economical and safe cleaning method. It is necessary to study the characteristics of scale and analyze the stress situation of the inner wall of water injection pipes and scale during the drilling and cleaning process, and optimize the design of existing drill bits for drilling objects to improve the scale removal capacity.

The Scaling Characteristics of Water Injection Pipe

According to the application of phase analysis theory, the composition of scale and the parts where scale forms are analyzed. From the perspective of multiple anatomical situations of scale forming pipelines, there are two kinds of situations of scale forming pipelines:

(1) Hard and compact scale formation on the inner wall of the water injection pipe, the main component of which is CaCO₃;

(2) It is mixed with impurities attached to the inner wall of the water injection pipe with dense structure, and the composition is soft oil mud and sandy soil, etc.

Based on the investigation of water quality and scale analysis, sandstone is selected as the calculation standard in design analysis. Sandstone is formed by quartz or feldspar particles, and its structure is stable, usually light brown or red, and it mainly contains silicon, calcium, clay and iron oxide components. The physical properties of the components are similar to scale, and the parameters of sandstone can be used to simulate scale in design analysis.

Drilling Design for Scale Removal

Chip Formation

Scale formation in water injection pipe belongs to brittle material, and the morphology of chip cannot be controlled as plastic material such as metal. Therefore, scale removal drilling can be analyzed by analogy with rock cutting process.

Bit broken composition is shown in figure 1, the mechanism of arrows in figure for the drilling direction, when drilling in water injection pipe to feed on the surface composition make cutting motion, bit blade to scale a shear force, composition under the action of shear force induced tensile stress, tensile stress exceeds the tensile strength of the composition, composition to produce tiny
cracks, the drill bit blade, under the joint action of crack increases, scale formation of debris, achieve the goal of removing [2].

Figure 1. Composition and broken mechanism.

Scaling Principle and Design of Scaling Bit

There are many differences between conventional drilling and descaling, which can be summarized as the following two points.

(1) drilling different object material, conventional drilling process for metal cutting object, belongs to the plastic material, drilling and descaling object for a mixture of CaCO$_3$ precipitation, silt, clay and so on, belong to the brittleness material, different physical properties compared with metal and forces on bit drilling process, drilling speed, chip form and chip removal are different. Compared with metal drilling, drilling and scaling removal process is more similar to drilling and rock breaking process [3].

(2) drilling object structure is different, the water injection pipe itself is not completely blocked by scale, there are 10~40mm diameter holes, and the hole wall ups and downs, not smooth, drilling and scaling should be a reaming drill.

Aiming at the machining object, the drill bit is designed to improve the cutting condition of the drill bit and reduce the cutting force by improving the structure of the drill bit and the arrangement of the cutter teeth. Specific improvement measures are as follows.

Figure 2. The blade structure diagram.

(1) The original structure of the 3 cutting teeth improved into 4, from the inside out are: inner sharp teeth, middle flat teeth, middle sharp teeth and outer teeth, where the inner sharp teeth and middle sharp teeth distributed on one side of the axis, middle flat teeth and outer teeth distributed on the other side of the axis (as shown in figure 2). By adding a cutter tooth, the tangential force and axial force received by the drill bit can be dispersed to improve the stress situation of the inner tooth.

(2) Remove the eccentricity of the original structure to reduce the radial force acting on the inner teeth. Inner sharp tooth and middle sharp tooth are of sharp tooth shape. During drilling, inner sharp tooth will form cutting countercone and annular groove on scale, which is conducive to positioning of drilling pin and plays a role of stabilizing drilling.

(3) Four chip liquid conveying channels are added on the bit body, two of which are on the side of the bit body, and the other two extend from the side to the front cone of the bit, ensuring the cooling effect and smooth discharge of chips. The grooved structure also reduces friction and wear during drilling.
The Water Injection Pipe Wall Stress Analysis

Modeling

In order to ensure the comparability of the research results, a model of the scale layer in the inner wall of the water injection pipe was established. During drilling and scaling removal, in order to avoid damaging the pipe wall during the machining process, there is a part of cutting margin between the outer edge of the drill bit and the pipe wall, forming the residual scale.

Stress Analysis

The water injection pipe wall model is analyzed using ANSYS software for water injection pipe wall stress nephogram as shown in figure 3.

In the axial stress diagram, the axial stress of the inner wall of the scale presents a annular distribution and decreases with the increase of radius. In the radial and tangential stress diagram, the radial stress and tangential stress distribution of the inner wall of the scale are similar, with the main cutting edge as the center and annular distribution, increasing with the increase of radius, that is, the free surface of the inner wall of the water injection pipe releases the stress.

Stress Diagram

The scale stress cloud diagram can directly show the three-dimensional distribution of scale stress, while the stress curve diagram shows the variation trend and characteristics of the stress from the quantitative aspect.

Stress curve is obtained by defining path analysis, we can fully reflect the characteristics of the new type descaling bit drilling process of stress field, so in the composition section of the model are defined on a stress path way1, as shown in figure 4 red line, its function is to display the drill special shaving and radial distribution law of internal three-dimensional stress, eliminate the radial distribution is used to understand a drill dirty work stress state of processed.

Stress graph as shown in figure 5, path of stress and negative figure illustrates composition under compressive stress, the curve of the Angle is bit workspace and the junction of tube wall, inside of the curve starting point for the tube wall and bit body contact, from the inner wall of the tube to stress state is the job of the bit body area of the junction of stress state, the junction of the lateral stress state for pipe wall.

As can be seen from the figure, with the increase of radius, the three stress curves decrease first
and then increase, among which the axial stress changes the most dramatically, the radial stress takes the second place, and the tangential stress changes the least. The three-way stress gradually changes to the original stress state value. In this area, the secondary stress field features of small radial stress and large tangential stress are formed, indicating that the radial stress is released sufficiently, and the tangential stress direction is the cutting direction of the drill bit, and the axial stress direction is the direction of applying drilling pressure, which is conducive to the drill bit to improve the drilling speed.

**Conclusion**

By analyzing the scale formation and characteristics of the scale substance, the computer software is used to simulate the force state of the scale substance in the inner wall of the water injection pipe, and the stress cloud diagram and path diagram are obtained. The simulation results directly show the drilling effect and the stress state of the pipe wall during drilling, while the stress curve shows the variation trend and characteristics of the stress in terms of quantity, reflecting the influence of the drilling process on the pipe wall, and providing data reference for comparative analysis of the experimental measurement values.

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