ON THE CASING WEAR MECHANISM IN DEEP AND ULTRA-DEEP WELL DRILLING

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ABSTRACT
Casing wear in the deep and ultra-deep well drilling is regarded as one of the most important technical problems in the petroleum exploration in the west of China. It is necessary to realize the casing wear mechanism for the solution of this problem. A tribo-system model for the deep section of the drilling-pipe and casing is presented based on log data and mechanics analysis in this paper. In the model the lateral vibration of the drilling-pipe is taken into account which can cause a great dynamic load on the casing. Then the tribological interaction relationships in this situation are built up. Moreover, the wear mechanism of impact-sliding contact surfaces between the casing and the tooljoints is revealed by combining theoretical analysis with the field monitoring tests. It is noticed that the surface contact fatigue play a very important role to speed up the casing wear. The results can provide guidance for actual wear prevention in the drilling engineering.

1. INTRODUCTION
Casings are cemented to separate the object layers from the terrane and support the well-wall in an oil or natural gas well drilling process. In general, the inner casing is subjected to the lateral loads from feeding and rotating tooljoints while drilling, resulting in wear which can reduce the casing thickness and intensity, bring on casing deformation or breakage and lead to severe drilling failures. In the western oilfields of China, casing wear in the deep or ultra-deep well drilling occurs frequently and is present as one of the pivotal factors leading to great drilling costs. The prevention of casing wear is considered as one of the most important problems in the drilling process. It is necessary to realize the casing wear mechanism for the solution of this problem[1].

Casing wear has been investigated systematically since the early 1970s. Through a lot of simulated experiments and field tests, casing wear in the straight well drilling was characterized as follows[2][3]:

(1) It was the rotation of drilling pipe that mainly caused the casing wear while the effect of its movement in the direction of well depth was tiny. There were higher lateral loads between the drilling pipe and the casing in the well sections with large dog-leg severities, which can cause severe casing wear. Large well dog-leg severity was the dominant reason of the casing wear.

(2) The main wear modes between the casing and drilling pipe were abrasion and adhesion. The casing wear rate lay on the lateral contact pressure and the rotation velocity, of which the lateral contact pressure between the casing and the drilling pipe was the key factor causing the wear.

(3) The casing wear followed so-called wear efficiency model, viz. the wear was in direct proportion to the friction energy transferred by the rotating tooljoints.

(4) As to a straight well, severe casing wear usually occurred on the sections with larger dog-leg severity and near the mouth where the maximum pull force existed in the drilling pipe.

Different from the wear occurring in a common straight well, the severe casing wear in the deep and ultra-deep well drilling in these area, usually takes place in the deep of well where the lateral pressure on the casing inner surface seems to be lower, sometimes even the dog-leg severity was very small. Current casing wear theory based on common straight well drilling engineering cannot only explain this phenomenon but also give proper guidelines to the prevention of casing wear in the well drilling process.

A new tribo-system model for the deep section of the drilling-pipe and casing is presented in this paper. In the model the lateral vibration of the drilling-pipe is taken into account which can cause a great dynamic load on the casing, and the tribological interaction relationships are discussed in detail for the explanation of the casing wear mechnism in the deep and ultra-deep well drilling.

2. THE TRIBO-SYSTEM MODEL
The lateral vibration of the drilling-pipe has been proven to occur very frequently in the deep of a well while drilling by a series of well detection experiments and is regarded as the dominant factors leading to fatigue failure of the tools and other equipment on the bottom of the drilling-pipe. However, there are almost no research given into the effect of the lateral vibration on the casing wear so far although many researchers...
have recognized that it is very important. In order to discuss this question, a tribo-system with the lateral vibration taken into account is presented. The schematic diagram of this system is demonstrated in Figure 1. The system is comprised of the tool-joint on the drilling pipe, the casing and the drilling mud with rock and metal debris. In the system, the drilling pipe movement is simplified as a combination of rotation and lateral vibration while the casing is fixed. Thus, the casing wear occurring in the deep of a well can be regarded as impact-sliding wear under the lubrication of multiphase drilling mud.

Figure 1. Schematic diagram of the tribological system

In general, the casing are mainly submitted to: (1) the impact and sliding friction of the drilling pipe in the compound motion of lateral vibration and rotation. (2) the squeeze and machining of the rock debris, metal debris and the other particles in the mud between two contacting surfaces. In this way, the casing wear could be complicated because of the existence of manifold tribological interactions.

3. DISCUSSION OF THE CASING WEAR MECHANISM

The lateral vibration of the drilling-pipe cause a great dynamic load on the casing. The process of impact-sliding casing wear can be described as follows. When the rotation drilling pipe makes an impact to the inner surface of the casing, the rock and metal particles are pushed onto the casing. Some of them wedge in the casing surface and abrase the surface. In the continual impact process, some micro-cracks may be generated on the casing surface and become stress-raisers. The high pressure from the drilling mud may expand the cracks. When these cracks connect through, the contact fatigue wear particles form and separate from the casing surface. The dimensions of some rock debris are so large that cause large-size wear particles generated. The typical wear mechanisms should be cutting wear, contact fatigue wear and adhesive wear. In fact, a series of wear debris collected from the drilling field in our casing wear monitoring tests (as shown in Figure 3.) have proven this viewpoint. But how this process occurs and how the lateral vibration affect the casing wear need to be understood by further simulated wear experiments.

4. CONCLUSIONS

(1) A tribo-system is presented to discuss the impact-sliding wear of the casing in the deep and ultra-deep well drilling.
(2) It is the intensive lateral vibration of the drilling pipe in the deep of the well that leads to the severe casing wear in the deep section of the well near the drilling pipe neutrality point where the stress is equal zero. The deeper the well, the more intensive is the lateral vibration of the drilling pipe.
(3) Further simulated wear experiments should be done to recognize the casing impact-sliding wear deeply.

ACKNOWLEDGMENTS

The author would like to thank the National Natural Science Foundation of China (NSFC) for supporting the project by providing funding (No.50475037).

REFERENCES