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Development of Gyroscope with Gas-dynamic Suspension of Ball Rotor

Nowadays, the problems of metrological drilling support are very perspective problem. The development of drilling technology is largely based on the application of the new and more improved information and measuring equipment which used for construction of wells. For realization of the perspective species of drilling are required to solve a number of problems: power control of the pipe string movement and its underground navigation and orientation.

The main task of navigation and orientation under the ground is determination of location drill body. Borehole navigation is based on the definition of orientation angles which are obtained from the inclinometric inertial navigation systems (borehole orientation systems) [1].

There are two types of borehole orientation systems: gyroscopic and magnetic. In recent years, magnetic systems have obtained the greatest distribution, because of their stability. But the magnetic devices have not high accuracy and such systems so complicated. Whereas, gyroscopic orientation systems have list of advantages, such as immunity to ferromagnetic masses and have not so sophisticated algorithms of processing than magnetic. But their application is constrained by presence of severe operating conditions.

As, the need in reliable and accurate borehole orientation systems very high, nowadays. And the main problem of this task is creation of the device`s heart – sensitive element.

During of developing inclinometric inertial navigation systems their size is rigidly limited – typically, for the majority of the tasks the length of the devices does not matter, but the well`s diameter is decisive for the choice of scheme and system`s sensitive elements.

The second decisive factor during of the developing is conditions of its operation: mechanical, climatic and also baric. Values of acting mechanical and climatic factors are: propensity to intense vibrations with frequencies which are found in the range from 10 to 300 Hz, with a maximum acceleration of 300 m/s^2; significant levels of blows (beats per minute from 10 to 50, with a duration of beats from 6 to 12 ms); the ambient temperature – from minus 40 ºC to 120 ºC or more; pressure up to 60 MPa or more.

The list of determined parameters for borehole orientation systems, typically a standard: determination of the zenith angle, the angle of rotation tool and azimuth or course angle. Accuracy requirement for inclinometric inertial navigation systems, especially for gyros, has value between 0,25–1 angular degrees, for storage`s accuracy or other way of recreation the indicating inertial direction.

Taking into account all the specific requirements, the construction of the ball gyroscope was developed and reliability and resistance to acting factors we decided to achieve using a special type of suspension – gas-dynamic bearings.

Ball gyroscope consists of the following main parts: the rotor is a standard ball bearing, which is placed between of two hemispherical bowls. The ball has an axial hole in the pole, where the movable elements of angle sensor are located. The response parts of angular sensor are mounted in an axial bore of bowls.

Spherical surface of bowls treated with a ball diameter, which is more than the actual diameter of the ball on 5 ÷ 10 microns. Thereby, the initial clearance is necessary for working in the regime of gas lubrication. The rotor is rotated by the electromagnetic field of the stator, which is powered by three-phase 36 Volts, with the frequency from 500 to 1000 Hz.

As the rotor rotates, gas, due to its viscosity, is involved in the initial gap between the bowls and the rotor. Further gas, which is inflow in the gap, creates an overpressure, whereby, the rotor «floats», and during its rotation at nominal speed mode provides constant gas lubrication.

Hemispherical configuration of the working surfaces of gas-dynamic bearing was chosen precisely because it is the most appropriate in terms of ensuring sufficient reserves for a bearing capacity and stiffness of the gas-dynamic bearings, as well as the stability of the gyroscope rotation axis [1].

The main principle of operation is: location of the drilling tool is determined in relation to geographically-oriented coordinate system. The coordinate system origin is located at the wellhead and the coordinates of its axis (well trajectory) are calculated by integrating the corresponding increments along the length of the well. The accuracy of the final result depends on the accuracy of the zenith angle, azimuth`s plane inclination of the tangent to the axis of the borehole and removing the measuring point from the wellhead (depth) [2]. For the implementation of geographically-oriented coordinate system, it is necessary that spin axis maintains its direction to the geographic North by the manner of a gyro compass. In this case, the gyroscope is an angular rate sensor measures the angular rate of the Earth`s rotation on the gyro sensitivity axis [3, 4].

The solution of the sensitive element development for borehole orientation systems will reach a new level in the problems of metrological support of drilling. There are many ways to achieve the main goal, but it is very important that sensitive element will be workable and maintain their accuracy properties under the acting severe factors during the working of the drilling tool.

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