UDC 622.245.59

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SENSORS FOR MEASURING THE SPATIAL POSITION OF WELLS

Gravity sensors. Gravity sensors used in inclinometers can be divided into two groups. The first group includes sensors that provide information about the direction of the gravity vector. These include various types of physical pendulum, float structures, where a float with a displaced center of gravity is located in liquid or in some other suspension (for example, magnetic, and prostatic, etc.); sensors with a solid ball on a concave surface and an air bubble under a spherical concave surface filled with liquid; sensors that use the horizontal property of the liquid level. The second group of sensors reacts to the magnitude of acceleration, in particular, the acceleration of gravity. These are so-called accelerometers.

The plumb line is the simplest zenith angle sensor of the first group. It is a load suspended at one point and deflected in all directions. In inclinometers that use a similar principle of measuring the zenith angle, the amount of deviation of the lower end of the plumb line from the longitudinal axis of the device is usually recorded [1].

The pendulum is also a gravity sensor. It can only deviate in one plane. In a state of equilibrium, the center of gravity of the pendulum lies on the projection of the gravity vector onto the plane of the pendulum's swing.

The spherical level principle is the basis of some gravity sensors. An air bubble in a spherical vessel filled with liquid tends to occupy the highest position. Data in such devices is usually captured photographically.

A ball on a concave spherical surface is used in gravity inclinometer sensors. A freely resting ball, under the influence of gravity, tends to occupy the lowest position. Gravity sensors with a ball on a spherical surface are used to measure zenith angles in a relatively small range. Data can be taken photographically to clearly record the position of the ball relative to a spherical surface on which a scale in the form of concentric circles is applied.

Mechanical fixation of the ball on a spherical surface is possible. An example of the practical application of such a sensor is a ball protractor. The protractor is designed in such a way that when the flushing liquid circulates, the steel ball rolls freely along the spherical concave surface. When circulation stops, the ball is fixed, and its position is determined visually after removing the protractor to the surface.

The property of horizontality of the free level of a liquid to determine the value of the zenith angle was used at one time in widely used instruments. The liquid level in these devices was recorded on the inner wall of a cylindrical glass, on the outer surface of a cylindrical rod, on a flat plate, etc.

The liquid level in the most common designs was recorded using hydrofluoric acid and a glass vessel. The property of hydrofluoric acid of a certain concentration to corrode glass was used. Hydrofluoric acid was poured into a glass vessel to about halfway. This vessel was placed inside a protective casing between shock-absorbing springs.

The device was lowered into the drill pipes on a rope or simply dropped inside the pipe string. After keeping the device at the bottom of the well for 15 minutes, it was possible to obtain a fairly visible trace of the hydrofluoric acid level on the wall of the glass vessel. After removal from the well, the device was disassembled, hydrofluoric acid was poured out of the vessel, and appropriate measurements were taken to determine the zenith angle.

The property of horizontal liquid level was used in the UZH-2 liquid inclinometer. The measuring device of this device included four pairwise communicating tubes, the cavity of which was filled with mercury up to half its height, and then with alcohol until it was full. The tubes were placed symmetrically relative to the longitudinal axis of the device. The protractor was placed in a sub, which was installed at the bottom of the drill string.

An accelerometer is a device for measuring linear accelerations and can be used to obtain information about the position of the inclinometer relative to the vertical. The sensitive element of the accelerometer is an inertial mass, the movement of which is limited by springs.

Accelerometers can be classified according to a number of characteristics. Depending on the structure, they can be of direct transformation and balancing (compensatory), depending on the nature of the suspension of the inertial mass - axial and pendulum. There are a number of other features that specify the design of the device, the number of degrees of freedom - one-dimensional, two-dimensional, three-dimensional; method of suspending inertial mass; type of inertial mass movement sensor; type of output signal, etc.

Gyroscopic sensors. In inclinometry, gyroscopic sensors are widely used. They are mainly used to determine azimuth. Their main advantage is that they do not require reference to the Earth's magnetic field and, therefore, can be used in wells where the surrounding rocks have magnetic anomalies, in cased wells, in high latitudes, where the horizontal component of the magnetic field is very small. A gyroscope is a rapidly rotating solid body whose axis of rotation can change its direction in space. In order to create the possibility of changing the direction of the gyroscope's rotation axis, the gimbal must provide it with several degrees of freedom. The most common case is that the gyroscope suspension provides three degrees of freedom (a gyroscope with three degrees of freedom). This version of the gyroscope can be implemented on the basis of a gimbal. The rotor of the gyroscope rotates relative to the casing, which simultaneously serves as the internal frame of the suspension. The casing can be rotated relative to the outer frame, which in turn can be rotated relative to the base, which is rigidly connected to the body of the device [4].

Magnetic field sensors. Magnetic field sensors, or magnetometric transducers, are classified according to the principle of using one or another physical phenomenon in them: magnetomechanical, induction, galvano-magnetic, kinetic, quantum, magneto-optical, etc. Magnetomechanical and induction transducers are the most common in inclinometers. Other converters, including galvano-magnetic ones, which include converters based on the Hall effect, which are widely used in the practice of magnetic measurements, as well as magnetoresistive ones, have not yet found application in the design of inclinometers.

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