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STABILIZER QUALITY INDICATORS
ПОКАЗНИКИ ЯКОСТІ СТАБІЛІЗАТОРА

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Abstract. *The work is devoted to the formulation of the main quality indicators of stabilizers.*
Key words: *stabilizer, quality indicators, moving object, accuracy, quality, stability.*

Introduction. Analytical review of the literature on stabilizers [1-3, etc.] does not contain information on determining quality indicators of stabilizers, which are absolutely necessary when solving problems of increasing the efficiency of stabilizers.

The task of this work is to formulate the main quality indicators of stabilizers.

Presentation of the main research material. The development of modern military equipment is marked by a significant increase in the speed and maneuverability of moving objects.

It is difficult to imagine the modern military sphere without the use of stabilizers. The relevance of stabilizers and the need for their improvement becomes special in a world where military conflicts and security threats are taking on increasingly complex forms.

Stabilizers are mainly used to keep the object in a stable position even during movement or external influences. These can be tanks, military helicopters, submarines, artillery systems and many other military weapons. Thanks to stabilizers, you can improve the accuracy of fire, increase the range of hitting targets and reduce the risk of a miss.

In a war zone where movement and danger are always present, the speed and reliability of stabilizers are vital. Without their help, it is difficult to imagine the successful execution of military tasks. Enemy actions can be unpredictable, so quick response and accurate weapon positioning become critical to mission success and the protection of one's own troops.

The need for constant improvement of stabilizers in the military sphere is an integral component of strategic security and effectiveness of military operations. Only thanks to the constant improvement of technologies and the introduction of advanced developments will we be able to ensure the safety of our military and defend our interests in the complex geopolitical conditions of the modern world.

The main tasks of stabilization and control of moving objects are solved with the help of gyroscopic stabilizers, the accuracy of work and other main indicators of which determine the efficiency of the functioning of the corresponding objects.

Three-axis gyroscopic stabilizers are designed to stabilize and control a platform with various devices installed on it relative to three stabilization axes.

Stabilization consists in determining the parameters of the angular position of the platform and creating the corresponding control signals.

Control of moving objects requires maintaining a given angular position of movement acceleration meters (newton meters) in space while meeting strict requirements for orientation errors. Three-axis gyrostabilizers are used to stabilize newton meters in space.

The main part of the three-axis gyro stabilizer is a stabilized platform, which has landing surfaces for mounting gyro blocks, newton meters.

In order to isolate the gyro-stabilized platform from the angular movement of the object, a system of semi-axes and frames is used, creating a three-stage gimbal suspension. The cardan suspension can provide two unlimited angles of rotation of the platform around the outer and inner axes, while the rotation around the middle axis of the suspension leads to a significant deterioration of the dynamic characteristics of the gyro stabilizer. Therefore, when choosing the location of the object, it is necessary to ensure that the angle of rotation around the middle axis is minimal and does not exceed 45-60°. At angles greater than 85°, a three-frame suspension is used.

The design of a three-axis gyro stabilizer is largely based on the method of designing a single-axis stabilizer, since from the point of view of the applied theory of gyroscopes, a spatial (three-axis) stabilizer can be divided into three one-dimensional channels of single-axis gyro stabilizers.

In connection with the development of computer technology, the capabilities of gyroscopic systems are expanding. This leads, as a rule, to the emergence of new structural solutions, at the same time increasing requirements for reliability, increased service life and reduced weight and dimensional characteristics.

Today, small-sized inertial navigation systems of the order of 10-15 kg are being developed, the testing of which on appropriate stands is impractical, since most of the stands for semi-scale testing of gyrostabilizers and elements of control systems of moving objects have very large dimensions and a weight of about 100 kg.

The problem of increasing the accuracy and other main indicators of such systems while simultaneously reducing the mass and geometric dimensions is one of the most urgent problems today.

The technical perfection of the stabilizers (C) is assessed by indicators characterizing the quality of its functioning both in the stabilization mode and in the guidance mode. The most important of them are the following [2-3, etc.]:

- stability;
- accuracy of stabilization;
- stabilization quality;
- pointing speed and nature of the distribution by the angle of rotation of the control panel;
- stabilizer readiness time;
- the time of continuous operation of the stabilizer, during which the technical characteristics correspond to the required values;
- reliability of functioning;
- the nature and time of transient processes when working out large angles of misalignment;
- energy efficiency;
- range of operating conditions.

Stability provides the main purpose of C, as an automatic control system, which consists in maintaining a given constant value of the regulated parameter or its change according to a defined law [3].

When the regulated parameter deviates from the set value (for example, under the influence of a disturbance or a change in the target), the regulator affects the system in such a way as to eliminate this deviation.

If, as a result of this influence, the system returns to its initial state or moves to another equilibrium state, then such a system is called stable.

If there are oscillations with increasing amplitude or there is a monotonous increase in error, then the system is called unstable [3].

Stabilization accuracy is the main indicator that characterizes the operation of the system in the stabilization mode.

External disturbances caused by continuous random oscillations of the body of a moving object cause the stabilizer to deviate from the specified pointing direction [2-3].

To quantify the accuracy of stabilization, the average values of the absolute angular deviations of the weapon stabilizer are determined - the average values of the stabilization errors.

The following are used as measures of accuracy of weapon stabilization systems [3]: - mean squared error; - average amplitude error.

The stabilization error is determined experimentally using special equipment and is measured in parts per thousand. The higher the accuracy of stabilization, that is, the smaller the deviation from the given pointing direction, the higher the quality of the stabilizer [3].

Modern Cs allow obtaining fairly high stabilization accuracy values (α = 0.6-0.8 thousand), which determines the high efficiency of target identification [2-3, etc.].

The aiming speed of a stabilized object when aiming or tracking a target characterizes the quality of the system in the aiming mode.

To accurately aim the weapon at the target, the actuators of the stabilizer must ensure the rotation of the object of regulation with angular velocities that smoothly change from values of 0.05-0.07 deg/s to 5-6 deg/s [2-3, etc.].

The dependence on the angle of rotation of the control panel in this range of pointing speeds should be linear (or close to it) with a gradient of change in angular speed of no more than 0.002 rad/s/degree [2-3, etc.]. This is necessary to ensure the possibility of continuous and accurate tracking of moving targets.

In order to quickly move a moving object when transferring from one target to another, it is necessary that the actuators ensure their rotation with angular velocities Q_{max} > 30-35 deg/s [3].

Stabilizer readiness time - the time interval from the moment the stabilizer is turned on to the start of its operation - is determined by the duration of the gyromotor acceleration process. For modern C, the readiness time is no more than 2 minutes. (includes switch-on time - up to 20 s) [3].

The time of continuous operation of the stabilizer is determined by the technical conditions during the execution of the task [1, 2].

The energy efficiency indicator reflects the electricity consumption of the stabilizer when performing its functions. More energy-efficient stabilizers ensure long-term operation from a single battery charge or reduce fuel consumption, which is especially important for portable or mobile devices.

The range of operating conditions indicates the range of external conditions in which the stabilizer can function effectively. It can include parameters such as temperature range, humidity, vibration, aerodynamic loads, etc. The wider the range of operating conditions, the more adaptable and reliable the stabilizer is.

Conclusions. Based on the analysis of the instrument composition, structure and dynamic parameters of blocks of well-known digital stabilizers, the main quality indicators of the stabilizer were formulated.

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Анотація. *Робота присвячена формулюванню основних показників якості стабілізаторів.*

Ключові слова: *стабілізатор, показники якості, рухомий об'єкт, точність, якість, стійкість.*

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