APPLICATION OF THE AUTOMATIC CONTROL THEORY FOR SEARCHING RATIONAL WAYS OF TECHNICAL DIAGNOSTICS AND IMPROVEMENT OF TECHNICAL CHARACTERISTICS OF 2E36 STABILISER

Abstract. The subject matter of the article is the process of troubleshooting a BMP-2 fire control system. The goal of the study is the development of a fault finding algorithm in this system and to offer suggestions for improving the technical characteristics of the weapon stabilizer based on the analysis of design and circuit solutions and technical characteristics of the BMP-2 fire control system. The tasks to be solved are: to conduct an analysis of the BMP-2 fire control system as a closed automatic control system provide suggestions for improving the performance of the stabilizer; to draw up a block diagram of a rational technical diagnostics of the 2E36 stabilizer and to propose a method for troubleshooting. General scientific and special methods of scientific knowledge are used. The following results are obtained. It is proposed to improve the technical characteristics of the 2E36 stabilizer by reducing the number of gyrotachometers from four to two with a parallel increase in the remaining signal branching, as well as improving the speed characteristics by installing an additional power source - a capacitor battery, for short-term and short-term engines. A rational technical diagnostics block scheme of the 2E36 stabilizer has been drawn up and methods of troubleshooting in the form of rigidity tuning cards, damping and vibration of the gun and turret stabilizer have been proposed. The diagnostic methods of elemental and group inspections are analyzed. Based on the analysis, the basic algorithms for the diagnostic process of tower and gun stabilization were developed. Thanks to this in the area of the task, personnel and repair units will be able to ensure the combat readiness of the equipment as quickly as possible. Conclusions. Gun stabilizers and turrets are closed automatic control systems based on the principle of adjusting the deviation of the adjustable value from a predetermined value. The objects of regulation in these stabilization systems are the cannon and the tower, and the adjustable values are their angular velocities. Feedback optimization involves reducing the number of gyrotachometers from four to two, which will increase the power reserve and give more opportunities for further stabilizer upgrades. Acceleration of the accelerator of the executive motor can be accomplished by installing a capacitor battery. The most long-term step in the process of repairing the complexity of complex systems is the process of finding failed items. The scheme of rational technical diagnostics provides the basic algorithms for carrying out the diagnostic process of stabilization of the tower and the gun, which allows to search for problems with maximum efficiency.

Keywords: armament stabilizer BMP-2; functional logic diagram; structural diagram of rational technical diagnostics of the stabilizer; methods of troubleshooting.

Formulation of the problem and research tasks

Diagnosis, troubleshooting, their repair and military repairs are decisive factors in the formation of the system of knowledge, skills and abilities, which depends on the technical state of armament and maintenance of combat readiness of combat vehicles in the units of the Armed Forces of Ukraine.

The fundamental side of this is to improve the technique of technical diagnostics in terms of optimizing the composition of diagnostic information used to make a decision, as well as reducing the time to formalize the process of processing the results of tests.

Therefore, the relevance of the work is due to the fact that in a limited time of military repairs, there is a need to develop simple and efficient algorithms for the diagnostic process.

Methodological basis of the study were general scientific and special methods of scientific knowledge. Namely:

– theoretical foundations of the theory of automatic control were used in the analysis of the functioning of the stabilizers of the gun and the BMP-2 turret as a closed SAR;

– methods of system analysis in determining the functional relationships between components and the disclosure of the order of operation and the development of a functional and logical scheme for turning on the system 2E36.

Analysis of recent research and publications. As usual diagnosis methods of complex systems are traditional.

Practice shows that the development of military repair of the weapons system is one of the most important issues in maintaining a high readiness of the weapons sample and is impossible without a qualitative analysis of the system individually and as a whole. With a large number of elements in the system and a malfunction, it is difficult to distinguish logical connections between the schema elements and the immediate causes that cause them.

Given that a large number of mechanized units of the Armed Forces of Ukraine have armed infantry vehicles BMP-2, there is a need for diagnostics and military repair of fire control systems of these vehicles. Usually, the diagnosis of complex systems is based on traditional methods of diagnosis. These methods include the using the schematic and installation schemes and reduced into certain system of possible faults and troubles (diagnostic tables) [1-3].

The relevance of the work is due to the fact that, as a result of a sufficient complication of the circuit and structural solutions of the weapons systems, the existing
diagnostic methods are not very effective. The main drawback of schematic diagrams is that they do not reflect logical but functional links between the diagnostic elements and the components.

Therefore, in order to improve the practical skills of crews of combat vehicles and engineering personnel, it is important to create a database of algorithms for diagnosing BMP-2 stabilizers.

The goal of this work is the developing a fault finding algorithm in this system and to offer suggestions for improving the technical characteristics of the weapon stabilizer based on the analysis of design and circuit solutions and technical characteristics of the BMP-2 fire control system.

To achieve this goal the following research tasks are proposed: to conduct an analysis of the BMP-2 fire control system as a closed automatic control system for improving the performance of the stabilizer; to draw up a block diagram of a rational technical diagnostics of the 2E36 stabilizer and to propose a method for troubleshooting.

General scientific and special methods of scientific knowledge are used.

Main material

1. Analysis of the functioning of the stabilizer 2E36 armament complex BMP-2 (Fig. 1)

The stabilizer is a combined automatic control system designed to direct and maintain with a certain accuracy the steady-state direction of the aiming line and the firing line of the gun in order to increase the efficiency of firing.

The 2E36 stabilizer is designed to increase the fire efficiency of a cannon and machine gun when firing on the go. The stabilizer provides the stabilized aiming of the gun and machine gun in two planes and the presentation of the target from the commander to the gunner in the horizontal plane.

The 2E36 system consists of two independently-acting stabilizers, a gun and a turret controlled by a common control panel. The main feature of these stabilizers is the absence of gyroscopic angle sensors. This feature, compared to traditional ones, can significantly increase the efficiency, reduce the weight and dimensions of equipment, as well as facilitate maintenance.

The fire control system depends on the position of the gun, for which the main sight sight BPK-2-42 is connected through the oscillation mechanism and the thrust with the gun 2A42. The drive vertical guidance (VN) provides stabilization and stabilized guidance of the gun and machine gun in the vertical plane of the VN. The drive of horizontal guidance (GN) provides stabilization and stable guidance of the turret in the horizontal plane of the GN.

The vertical guidance drive includes gyrotachometers GT-VN, GT-K (compensation), a tachometer TG-VN, a current sensor DS-VN, an amplifier for U-VN, and limit switches.

The principle of action of the gyrotachometer is based on the properties of stability and precession of the gyroscope, which when untwisted hydromotor to keep its non-changing position of the axis of rotation in space.

The horizontal guidance drive (HS) includes a GT-GN gyro tachometer, a current sensor DS-GN, a P-GN signal amplifier, a PCV targeting device, a gear reducer with a drive actuator and a drive clutch, a limit switch. The GT-GN measures the gun fluctuations with the tower in the GN plane [4-7].

2. Suggestions for improving the technical characteristics of the 2E36 stabilizer by its partially upgrading

From the analysis of the stabilizer 2E36 it follows that the flexible feedback in this sample is provided by four gyro tachometers and one tacho generator, the sum
of signals from which allows to obtain the angle of disagreement between the sight line of sight and the axis of the bore of the gun barrel.

Gun stabilizers and turrets are closed self-regulating systems based on the principle of adjusting the deviation of the adjustable value from a predetermined value. The objects of regulation in these stabilization systems are the gun and the tower, and the adjustable values are their angular velocities \( \Omega_G \) and \( \Omega_T \). For the formation of signals \( U_{\Delta b} \) and \( U_{\Delta w} \) equivalent to the angle of disagreement between the aiming line and the axis of the gun, signals from four gyro tachometers and one tachogenerator of gun and tower stabilizers, which are equivalent to angular velocities \( \Omega_G \) and \( \Omega_T \) are given in the control unit integrator.

Feedback optimization involves reducing the number of gyrotachometers from four to two, which will increase the power reserve and provide more opportunities for further modernization of the stabilizer. Acceleration of the actuator can be achieved by installing a capacitor bank.

As the stabilization of the BMP-2 weapons is rapid, the main function in its implementation is played by gyro tachometers.

The signals from GT-VN and GT-GN come through the integrator to form a discrepancy angle, in addition they branch out and the signals are proportional to the velocities of the gun and the turrets arrive at the adders.

With GT-K, the adder receives a signal proportional to the velocity of the tower in the vertical plane, and with TG - a signal proportional to the velocity of the gun relative to the turret.

From GT-K the adder receives a signal proportional to the speed of the tower in the vertical plane, and from TG - the signal is proportional to the speed of the gun relative to the tower.

However, at this stage in the development of this type of equipment, it is inappropriate to use such a number of gyrotachometers, especially considering that in the new stabilizers of the SVU-500 series, their number is reduced to two. Another important argument in this direction is energy costs. Gyrotachometers are powered by a voltage of 36 V at a frequency of 400 Hz from a PT-200C voltage converter. The power spent on each power is about 20 watts. Therefore, reducing their number will increase the power reserve, thereby giving more opportunities for further modernization of the stabilizer.

The analysis allows us to obtain the necessary data for reconnecting the gyrotachometry GT-VN and GT-GN data, based on which a connection diagram for gyrotachometers (Fig. 2) is developed taking into account the reduction in their number.

With this switch, two speedometers can be used to prevent the stabilization of the robot, and all signals will be ignored and the main voltages come before the GT-K and GT-SAW signals are sent to the rods. We can respect this, but we’ve broken up the scheme for giving a complete solution.

Of course, it’s possible to accelerate the overclocking of the hitchhiker dvigun for the additional installation of a capacitor bank.

3. Drawing up a rational technical diagnostics block scheme of the 2E36 stabilizer methods of troubleshooting

Technical diagnostics studies and develops processes for the rational determination of the state of technical objects. With regard to the system of stabilization of armament, diagnostics allows the optimal (in time and means): to determine the true technical state of the system, the accuracy of transmission and processing of informative signals in it, localize the location and identify the cause of failure (failure) in the scheme, to predict the system's performance in the future.

In general, the solution to the problem of troubleshooting depends on the volume and reliability of the information obtained when assessing the status of the BMP-2 weapons stabilization system. In the practice of operation, the condition assessment can be carried out on the basis of the results of checking the serviceability, efficiency or correctness (quality) of the system functioning.

The element-by-element check of the stabilizer involves checking the elements one at a time in a predetermined sequence. Each check has two results: either the item is working or not. If the element that is being tested is defective, then the next element is checked, and so on until the fault is detected [8, 9].

Choosing the appropriate inspection method involves in-depth knowledge of the composition and operation of structural and functional circuits of stabilizers. The group check method involves the simultaneous checking of a group of elements that may contain a failing element. If the test gives a positive result, we conclude that the faulty element is in the group being tested, and the latter is again divided into two groups and the fault is searched among the elements of these subgroups.

Thus, on the basis of the analysis of the 2E36 stabilizer, as an object of diagnostics, the methods of element and group checks, and using the general principles of construction of algorithms for carrying out the diagnostic process, the structure of rational technical diagnostics of the stabilizer is presented, which is outlined in Fig. 3.

Conclusions

Gun stabilizers and turrets are closed automatic control systems based on the principle of adjusting the deviation of the adjustable value from a predetermined value. The objects of regulation in these stabilization systems are the cannon and the tower, and the adjustable values are their angular velocities.

Feedback optimization involves reducing the number of gyro tachometers from four to two, which will increase the power reserve and give more opportunities for further stabilizer upgrades. Acceleration of the accelerator of the executive motor can be accomplished by installing a capacitor battery. The most long-term step in the process of repairing the
complexity of complex systems is the process of finding failed items. The scheme of rational technical diagnostics provides the basic algorithms for carrying out the diagnostic process of stabilization of the tower and the gun, which allows to search for problems with maximum efficiency.

Fig. 2. Electrical connection scheme of the gyrotachometers GT-VN and GT-GN
Fig. 3. Structure of rational technical diagnostics of 2E36 stabilizer

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Accepted for publication (Прийнята до друку) 28.08.2019

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Використання теорії автоматичного управління для пошуку раціональних шляхів технічної діагностики та покращення технічних характеристик стабілізатора оброни 2Е36

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А нота ція. Предметом дослідження є процес пошуку несправностей в системі управління огнем БМП-2. Метою дослідження є на основі аналізу конструктивних і схемних рішень та технічних характеристик системи управління огнем БМП-2 розробити алгоритм пошуку несправностей у даній системі та надати пропозиції щодо покращення технічних характеристик стабілізатора оброни. Завдання: Провести аналіз системи управління огнем БМП-2 як замкненої системи автоматичного регулювання; надати пропозиції щодо покращення технічних характеристик стабілізатора; скласти структурну схему раціональної технічної діагностики стабілізатора 2Е36 та запропонувати методику пошуку неполадок. Отримані такі результати. Запропоновано покращення технічних характеристик стабілізатора 2Е36 за рахунок зменшення кількості гіротахометрів з чотирьох до двох з паралельним збільшенням розгалуження сигналів від них, що залежалися, а також покращення швидкісних характеристик за рахунок встановлення додаткового джерела живлення – конденсаторної батареї для короткочасного збільшення потужності та скорочення часу на розгон двигунів. Складена структурна схема раціональної технічної діагностики стабілізатора 2Е36 та запропоновані методики пошуку неполадок у вигляді карток налаштування жорсткості, демпфування та вібрації стабілізатора гармати та башти. Проаналізовані діагностичні методи поєднаних і групових перехідників. На основі аналізу розроблені основні алгоритми для проведення діагностичного процесу стабілізації башти і гармати. Завдяки цьому у зоні виконання завдання особливий склад та режими підходи змогуть максимально швидко забезпечувати боєготовість техніки. Висновки. Стабілізатори гармати і башти являють собою замкнені системи автоматичного регулювання, які ґрунтуються на принципі регулювання по відхиленню регульованої величини від заданого значення. Об’єктами регулювання в цих системах стабілізації являються гарма (і башта, а регульована величина – їх кутові швидкості. Оптимізація зворотного зв’язку передбачає скорочення кількості гіротахометрів з чотирьох до двох, що дозволить збільшити запас потужності і дасть більше можливостей для подальшої модернізації стабілізатора. Припинення розгону виконавчого двигуна можливо здійснити за допомогою встановлення конденсаторної батареї. Найбільші провоковуваним етапом в процесі відновлення справності складних систем є процес пошуку елементів які відмовили. Схема раціональної технічної діагностики передбачає основні алгоритми для проведення діагностичного процесу стабілізації башти і гармати, що дозволяє проводити пошук неполадок з максимальною ефективністю.

Ключові слова: стабілізатор оброни 2Е36-2; функціонально-логічна схема; структурна схема раціональної технічної діагностики стабілізатора; методики пошуку неполадок.