Algorithm for diagnosis of the tank weapon stabilization system "Complex 2E28M" in „Targeting“ mode

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Abstract. The latest trend in the development of combat equipment is the increasing penetration of automated and automatic systems with a variety of purposes. In its bigger part, these systems include electrical machines, electrohydraulic, electronic and gyroscopic units and assemblies. The considerable complexity of the electro-automation of machinery, even with high reliability, leads to an increase in the probability of the occurrence of failures and the need to increase the requirements for the qualification of the engineering staff of the repair staff.

The study of diagnostic and repair issues of electro-automatic systems is based on the knowledge of the faults occurring in the systems in the process of their operation.

The faults of the systems by the cause of occurrence can be divided into: faults resulting from wear and ageing of parts and components; faults resulting from construction errors and from low quality of manufacture; faults resulting from poor quality of servicing and repair; faults resulting from insufficient qualification of the operating personnel.

Failures of systems in terms of their operability can be divided into: failures altering the characteristic of systems and deteriorating the quality of their operation; failures leading immediately to the shutdown of systems; failures directly affecting the quality of operation of systems, their characteristics and subsequently leading to their complete shutdown.

System failures can be divided into: failures requiring repair of the system by replacement of the failed units and assemblies; failures requiring repairs without replacement of the units and assemblies; failures that were being repaired in the process of operation and maintenance of the systems.

Before carrying out an emergency repair of the electro-automation, it is necessary to determine the nature of the fault and to specify as precisely as possible the location of the faulty element or component in the electrical, hydraulic or kinematic circuitry of the electro-automation.

The purpose of the survey is to provide the operating personnel with a sequence of actions which result is in the detection of the fault or qualified personnel to be directed to the most likely faulty component.

An algorithm for diagnostics of the "Complex 2E28M" tank weapon stabilization system in the "Target Designation" mode is presented. The algorithm is built by using the "Failure Tree" method to determine the state of complex technical systems.

The advantages of the presented method of initial diagnostics are that it is possible for the crew with their own forces and means to detect small failures in the weapon stabilization system. On arrival of the specialised repair bodies, the crew directs them to the most likely cause of failure. In this way, all possible causes of failures in the system are tracked, providing instructions to the operating staff for elimination of the possible failures that have occurred. Using this method the time for product diagnostics is significantly reduced.

Keywords: Algorithm, Automatic systems, Diagnostics.

I. INTRODUCTION

The quality of operation of the automatic systems in the tanks guarantees their high combat efficiency and the fulfillment of their assigned tasks. The accuracy of hitting moving targets to the greatest extent (in purely technical terms) depends on the weapon stabilization system (WST). For this reason, it is a subject of numerous studies. For the needs of the research work and the increase of the efficiency of STV, it is necessary to determine how the individual constructive parameters affect the quality of stabilization.

For indicators of the quality adjustment, the change in the reserve of stability and the speed of action are monitored.

Margin of stability refers to the quality of automatic control systems (CAP) in the non-established modes of operation, being determined by the type of process under some typical setting or disturbing effect.

The stability margin characterizes the tendency of the system to oscillate. The more oscillations the process has, the smaller the margin of stability. Its value is determined by the maximum value of the adjustable quantity referred to its established value after the transition process has taken place [1].

Print ISSN 1691-5402
Online ISSN 2256-070X
https://doi.org/10.17770/etr2024vol4.8199

The value of the reregulation depends on the features and requirements of the regulated object (process). It is usually 10% to 30%, but can be outside these limits on some systems. In some cases, reregulation is not allowed at all, which means that oscillations in the system are also inadmissible.

The transient process curve is used to determine the speed of the systems. Fastness indicates the ability of the system to monitor changes in the input (setting) impact. It is defined as the time for which the adjustable quantity reaches a value different from the set one with the advanced set small quantity.

Some other indicators of the transient process curve, such as the time of –growth, are also used to assess the rapidity of action. It is defined as the time necessary for the system to reach for the first time the established value of the adjustable quantity, counted from the moment of application of the setting impact [2].

If there is necessity of deeper analysis the system is required, the identified transmission functions of the electronic amplifier [3], the speed sensor [4], of the angle sensor [5], the hydraulic vertical guidance system [6] can be used, as well as the built and checked for adequacy mathematical model [7] and diagnostic model [8] of the tank armament stabilizer "Complex 2E28M".

To analyze the processes due to the oscillations of the tank body during its movement, the emerging vibrodynamic processes, and their influence on the quality of stabilization of the armament, an analysis of the system using the finite element method is used [9] - [11].

The stabilizer of the tank weapon (STA) "Complex 2E28M" is installed on the T-72 medium tank and its modifications. "Complex 2E28M" is an electro-hydraulic automatic system providing stabilization and guidance of the cannon and the machine gun paired with it in vertical and horizontal planes. It is designed to increase the effectiveness of fire when firing tank weapons while moving. The STA works together with the TPD-2-49 or Quantum TPD-K1 optical sight-rangefinder and the automatic gun loader. Also with the planned thermal imaging observing and measuring devices in the ongoing modernization of the T-72 tank in the Bulgarian Army.

The STA consists of two electro-hydraulic tracking drives: a vertical guidance drive (VD) and a horizontal guidance drive (HD). VD stabilizes the swinging part of the cannon in a vertical plane, and HD stabilizes the turret with the weapon in a horizontal plane.

As a result of the stabilization during the movement of the tank on rugged terrain, the weapon maintains the set position in space, while the tank body fluctuates in the vertical and horizontal planes (VP and HP). At the same time, during the stabilization, the elevation angle of the gun in VP and the azimuth angle in HP can be changed by the rangefinder operator using the control panel located on the sight-rangefinder.

The main modes of operation of the STA are "Semi-automatic", "Automatic" and "Targeting". "Semi-automatic" mode provides unstabilized aiming in HP and manual aiming of weapons in VP. "Automatic" mode provides stabilization and guidance of weapons in VP and HP. "Target Designation" mode provides guidance of weapon to a target selected by the tank commander. In this mode, the commander takes control of the HP from the gunner and directs the cupola at maximum speed to a target of his choice. During targeting, the gunner receives a light indication. Targeting can be used during STA operation in "Automatic" and "Semi-automatic" modes.

In order to quickly and accurately identify the defective elements and units in the automatic system, it is necessary to create an appropriate action algorithm. The application of this algorithm will greatly facilitate service personnel in detecting the causes of system failure.

II. MATERIALS AND METHODS

In its composition, "Complex 2E28M" includes a number of electrical machines, electrohydraulic, electronic and gyroscopic units and assemblies. The significant complication of STA, even with high reliability, leads to an increase in the probability of the occurrence of failures and the need to increase the requirements for the qualification of the engineering staff of the staff. The study of questions about the diagnosis and repair of electro-automatic systems is based on the implementation of operational methods and the knowledge of malfunctions that occurred in the systems during their operation.

Before carrying out an emergency repair of the electrical automation, it is necessary to determine the nature of the malfunction and specify as precisely as possible the location of the damaged (obsolete, worn) element or detail in the electrical, hydraulic or kinematic scheme of the electrical automation.

In the event of a loss of operability of the electrical automation or a separate system of its with obvious external damage the following is carried out:

- Detailed external examination in which additional and other obvious malfunctions could be detected;
- Removal of all external damages for which dismantling of main blocks is required.
- Checking off the functionality of the electro-automatics, which gives opportunity to detect any internal damage before proceeding to dismantle main blocks;
- Dismantling of the main blocks in which there is external or internal damage;
- Checking the dismantled blocks using special equipment. This check is carried out in the presence of specialized diagnostic equipment;
- Installation of the blocks;
- Checking the operability of electro-automatic in all modes of operation.
- Targeting mode is activated in the following sequence:
- Turns on STA in "Semi-automatic" or "Automatic" mode;
- The commander's cupola is locked. If it is locked, Target mode does not work;
- Aim the commander's sighting device at the target and hold it there;
- The targeting buttons located on the left and right grips of the commander's observation instrument are pressed. At the same time, the control of the cupola from the gunner is transferred to the commander, and the "Commander" signal lamp lights up on the signal board of the sight-rangefinder. When buttons are pressed, the turret rotates at maximum transfer speed to the target. Upon reaching the direction of the target, the turret stops its movement;

➢ After the cupola stops, the buttons are released. This extinguishes the "Commander" signal light and the control of the guidance of the cupola is transferred to the gunner. It carries out the precise guidance of the weapon to the target.

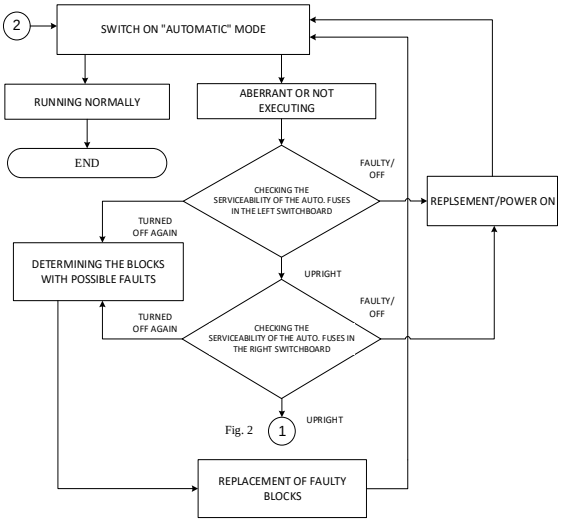

Fig. 1. Algorithm /first part/ for diagnosis of STA in "Targeting" mode.

III. RESULTS AND DISCUSSION

To detect the block in which a failure occurred, it is necessary to apply the algorithm shown in figures 1, 2, 3 and 4 for diagnostics of STA in the "Targeting" mode, based on the algorithm for diagnostics in the "Auto" mode [12].

For this purpose, the activities of preparing the system for inclusion are carried out, then in strict sequence, the STA is turned on in "Automatic" mode.

In the sequence of the algorithm, the elements for control in case of failure or atypical operation of the system are specified.

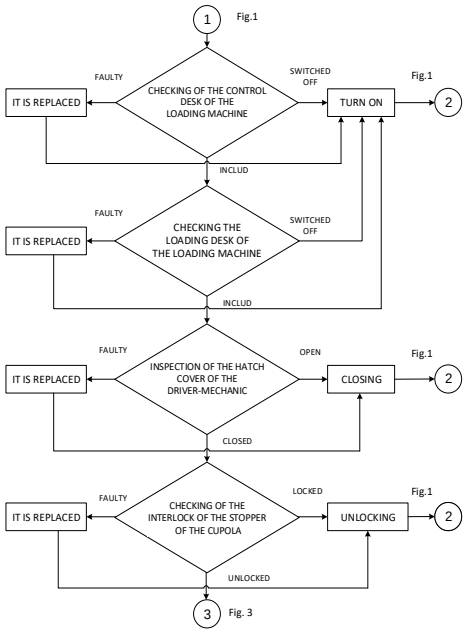

Fig. 2. Algorithm /second part/ for diagnosis of STA in "Targeting" mode.

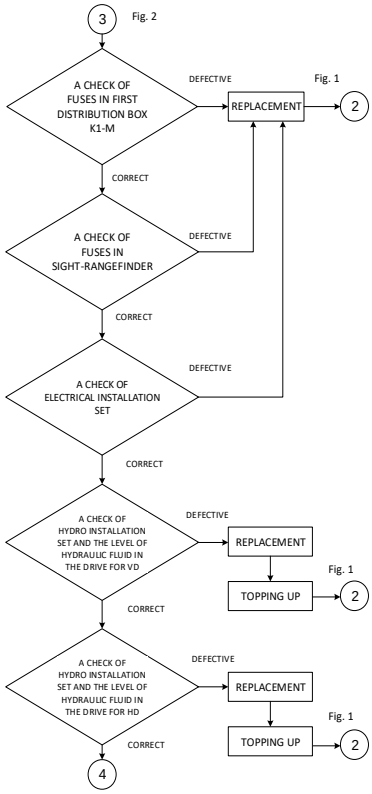

Fig. 3. Algorithm /third part/ for diagnosis of STA in "Targeting" mode.

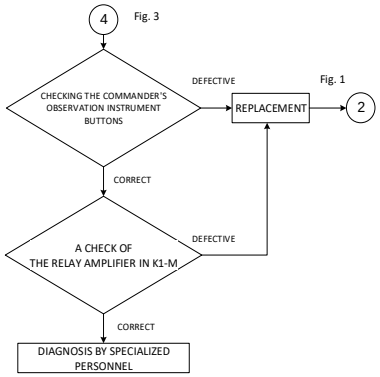

Fig. 4. Algorithm /fourth part/ for diagnosis of STA in "Targeting" mode.

During switching on of the STA, in the absence of specialized equipment, the fault is localized by the method of replacement: one by one, the blocks identified as possibly faulty are dismantled, in their place, serviceable blocks from the stock are installed and the operability of the electrical automation after each successive shift is checked. Restoration of operability is an indication that the replaced unit is damaged. If operability is not restored, another unit or several units are damaged at the same time. In such a case, complete and accurate conviction of the location of the damage can be achieved by checking the operability of the STA by successively changing all possible combinations of the recorded blocks.

If specialized equipment is available all blocks that are identified as possibly faulty are checked. If they are found to be working, the remaining blocks and all connecting wires and plug joints are checked. Damaged blocks are dismantled and replaced with new or repaired ones.

No other literature is available on this problem for this particular system.

CONCLUSIONS

1. Adhering to the proposed algorithm, it is quite possible with the forces and means of the crew to discover the reason for the malfunction of the weapon stabilization system and to locate the faulty unit, without using specialized diagnostic equipment and highly qualified engineering and technical staff.

2. The widespread introduction of automatic systems in combat equipment, on the one hand, leads to an increase in its efficiency and convenience in operation, but on the other hand, the probability of failures due to which it cannot fulfil its functional purposes increases.

3. The developed diagnostic algorithm will increase the efficiency of the technical staff during the repair and restoration activities when eliminating the troubleshooting of the automatic weapons control systems.

ACKNOWLEDGEMENTS

This research is supported National Science Program „Security and Defense”, adopted with RMS No. 731 of 21.10.2021 and according to Agreement No. D01-74/19.05.2022.

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