DEVELOPMENT OF AN AUTOMATED CONTROL SYSTEM FOR MONITORING AND RESEARCH OF AN ELECTROHYDRAULIC STEERING GEAR

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Abstract

The paper provides a description of the electro-hydraulic steering gear and the principle of its action. The paper shows the development a mathematical model of the steering gear and the control system of the steering gear is given in the Simulink program of the MATLAB package. Based on mathematical model develop a real control system and show it block diagram with a description of its components.

Keywords: hydraulics; steering gear; matlab; control system; mathematical model

1. Introduction

The paper consider the development of an automated control system that is used for checking operation of an electrohydraulic steering gear and to explore its parameters. The steering gear is defined as one of the parts of the rocket that controls its flaps. The development is made for one of the types of the rocket which is produced at one of factories in Russia.

Most industries in Russia now uses manual control systems which have a number of significant weakness: the complexity of use, slowness, the occurrence of errors as a result of the human factor. Development of an efficiently working automated control systems allows to increase the productivity and reduce the number of staff. This increases the speed of information processing and its reliability, which is necessary for effective planning and management. With the beginning of an enormous increase of steering gear production, the need to use automated digital control systems is very relevant, as they can significantly increase the speed of checking the desired parameters, such as idle speed, phase shift, frequency response, and reduce the complexity of the study[1].

The purpose is to develop an automated control system of an electro-hydraulic steering gear that meets modern standards and which will allow to avoid human factor errors and increase the speed of research

2. Steering gear and its mathematical model

The developed control system is designed to control the steering gear, the scheme of which is shown in Fig. 1. The gear is an independent electro-hydraulic variable pressure drive, once refilled with a working fluid and not requiring refueling during the entire life cycle [10]. The gear is designed to control the executive device of the rocket flaps [6] [7].

Fig. 1. The scheme of the electro-hydraulic steering gear: 1 - filling valve, 33 - reducing valve, 3 - make-up valve, 4 - filter, 5 - safety valve, 6 - electromagnet, 7 - throttle, 8 - bushing, 9 - throttle, 10 - slide valve, 11 - hydraulic cylinder, 12 - feedback mechanism, 13 - feedback sensor, 14 - plunger, 15 - pump, 16 - electric motor, 17 - compensating suppressor device.

This chapter provides a mathematical description of the steering gear with a mathematical description of its individual components - an electro-hydraulic power amplifier, a power plant that includes a pump with a feed regulator as a function of discharge pressure and an electric motor[8].

Fig. 2. Mathematical model of steering gear

The assumptions adopted while simulation:

1. The hysteresis of the static characteristic of an electromechanical transducer $P(i)$ is not taken into account and $P(i) = 0$;
2. The compressibility of the working fluid connecting the valve with the hydraulic cylinder is neglected;
3. The microgeometry of the slide valve pair is not taken into account.

To solve the system of equations was used the MATLAB package Simulink program [2]. The scheme of the steering gear in the program Simulink package MATLAB presented in Fig. 2.

The scheme of each parameters is placed in the subsystem for more convenient perception. Each subsystem is built on the basis of a system of equations. For example, below is the equation of an electric motor where the input signal is current I and the output is the speed of rotation of the motor ω (1).

$$\begin{cases} \frac{d\omega}{dt} = T_{s1}(I - I_{xx}) - T_{s2} \left[M + \frac{Q_m \Delta p}{2\pi n} \right] - T_{s3} \omega; \\ \frac{dI}{dt} = T_{s4} U - T_{s5} \omega - T_{s6} I. \end{cases} \quad (1)$$

According to equations we made a scheme in Simulink of electric motor of steering gear (Fig. 3.).

Fig. 3. Mathematic model of electric motor

3. Mathematic model of the control system

To imitate the control system of the steering gear mathematical model was made (Fig. 4). For clarity, the model of the control system is divided into 3 areas [5]. The «control system interface» part simulates a real interface and generates a digital control signal that goes to a PC.

The «control system of the steering gear» part simulates a real controller, where the digital signal is converted to analogue if we send a signal to the block, and vice versa, if we receive a feedback signal from the block. Also, the device is coordinated by selecting the necessary coefficients and closing/opening the feedback with the help of the Switch relay [3][9]. The scheme of the steering gear is placed in the subsystem for more convenient perception.

Fig. 4. Mathematical model of control system

4. Control system of steering gear

The control system of the steering gear generates control signals, controls the steering gear parameters, provides reception, processing and issuing information about the steering gear functioning in accordance with special software which I also developed in C++ language[4].

The formation and control of the testing programs of the control system are carried out using a PC. The display of the necessary information on the screen when setting the required test mode, its progress and test results is provided by software, which is downloaded in the controller's memory. The block diagram of the control system of the steering gear is presented in Fig. 5. The transmission of control information from the PC to the control system and the reception of control reports is carried out using the RS-232 interface. RS-232 (Recommended Standard 232) - a standard describing an interface for serial bidirectional data transfer between a computer and an end device.

The control system provides:

- control of parameters and operation of the steering gear;
- generating a test report of the steering gear in the form of a text file.

Fig. 5. Block diagram of the control system of the steering gear

The controller is powered from an external power source with a voltage of + 27V. The control signal in a digital code comes from the PC via the RS4-104 communication module to the controller, where we download the program. Next, the signal is converted from digital to analogue and the control block enters the electromagnet of the steering gear in the form of a control current.

The hydraulic cylinder rod starts to move and data from the feedback sensor is sent to the matching block, where the input and output parameters of the block are compared. Next, the result enters the program and the result is shown on the screen. The complex control program is written in C ++ language for control, data entry, setting operating modes and interface parameters. After recording the input data one of the considered parameters the PC automatically monitors this parameter. After determining the process of forming a report on the state of the tested parameters of the steering gear ("OK" or "Not OK") with indication of the measured parameters. The test results are saved in a file in the computer.

5. Conclusion

There was an aim to developed an automated control system of the electro-hydraulic steering gear. The necessary components were selected, there were developed algorithms to control the necessary parameters while testing a real steering gear. Mathematical models of the steering gear and control system were made in the Simulink environment of the MATLAB software package. Future plans are to make a comparative analysis of the characteristics of the real control system and its mathematical model. Try to improve the structure of system if necessary and to develop an algorithm to control other parameters of the steering gear such as load speed, torque, stabilization and other.

6. References

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