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INSTALLATION OF MONITORING OF TECHNOLOGICAL PROCESSES IN THE OIL AND GAS INDUSTRY TO PREVENT ENVIRONMENTAL DAMAGE

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Abstract: the article presents the process of constructing a mathematical model of a universal hydraulic stand. The structure of the stand, including the main hydraulic elements, sensors and actuators, is described. Methods of mathematical modeling of hydraulic components in the form of pumps, hydraulic accumulators, valves, pipelines are considered. The developed model makes it possible to simulate the operation of a hydraulic system, analyze its dynamic characteristics, and optimize control parameters. Keywords: hydraulic stand, mathematical modeling, hydraulic system, dynamic model, simulation modeling.

Keywords**:** environment, modeling, pressure, leakage, regulation, oil pipeline.

Introduction

The modern oil and gas industry faces significant environmental challenges associated with potential hydrocarbon leaks, pipeline accidents, and other emergency situations that can cause substantial damage to ecosystems. Preventing such incidents requires not only advanced monitoring technologies but also the development of precise methods for modeling and analyzing potential risks. This article presents an automated monitoring installation for technological processes in the oil and gas sector, designed to minimize environmental damage. The primary objective of this work is to develop a mathematical model of a universal hydraulic test bench capable of simulating fluid and gas leaks, as well as other emergency scenarios in pipelines. The article provides a detailed description of the test bench structure, including key hydraulic components, sensors, and actuators. Methods for mathematical modeling of system components such as pumps, hydraulic accumulators, valves, and pipelines are examined. The developed model enables simulation of hydraulic system operation, analysis of its dynamic characteristics, and optimization of control parameters.

Installation Description

One of the main goals of the universal hydraulic installation under consideration is the study of high-order hydrodynamic processes in the theory of automatic control [1]. To implement it, it is necessary to present the entire hydraulic part of the installation in the form of a mathematical model, correctly form and define the main links of this model, and calculate the transfer functions of control objects. This section presents mathematical models developed to describe the operation of the hydraulic system of the installation. Starting with simple models of individual components, such as a hydraulic accumulator, a pump, and regulated leaks from working fluid storage tanks, with further progress to more complex models describing the relationship between system elements [2]. A detailed description of each model includes a review of its main mathematical blocks, the mathematical equations used and their scope.

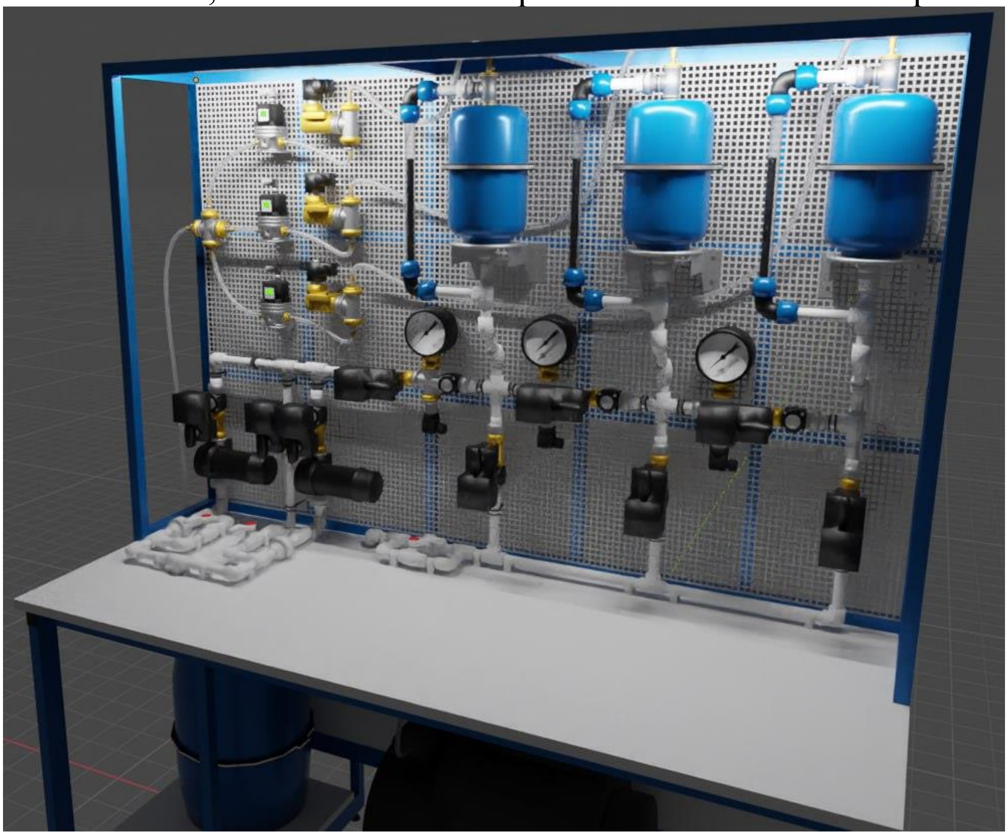

Figure 1. Three-dimensional design model of the installation

According to the structural structure, the developed mathematical model can be divided into five main mathematical blocks: pump pumps, hydraulic accumulator of the 1st section, hydraulic accumulator of the 2nd section, hydraulic accumulator of the 3rd section, regulated leaks. Dividing the system into separate blocks makes it possible to simplify the analysis, more accurately model the behavior of each element and investigate their mutual influence. The mathematical models of the two pump pumps are identical to each other and are shown in Fig. 2.

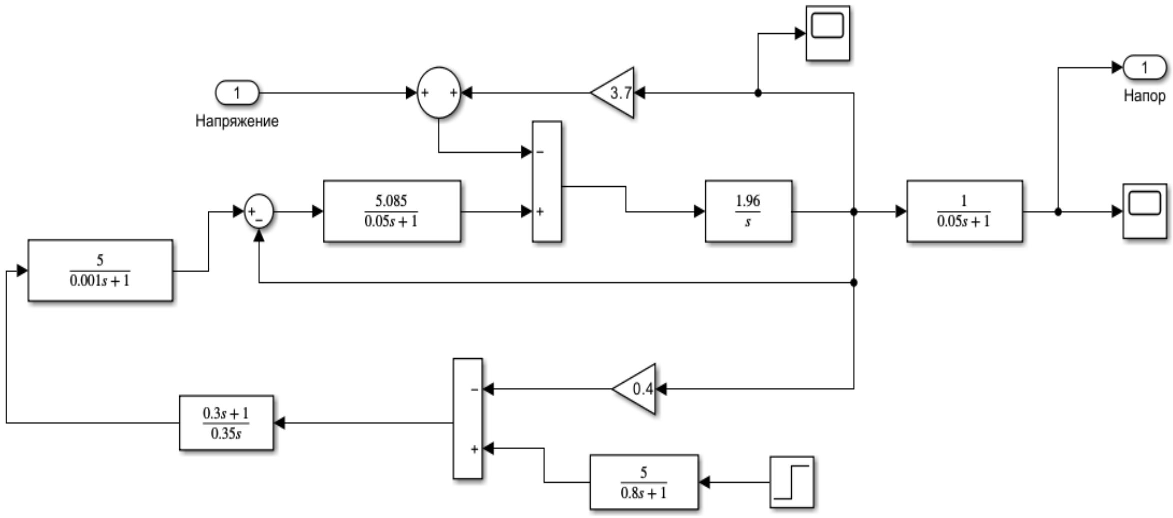

Fig. 2. Mathematical model of a pump

The setpoint of the system is a constant value, which represents the setpoint of the overpressure variable in the atmosphere, which in essence is the setting effect for the presented model [3]. The adder adds or subtracts the input signals depending on its own sign. This model features two different adders – one performs the function of adding two input signals, the second subtracts the second input from the first and outputs the result, thereby subtracting feedback to generate a control error signal. Next comes a series of first-order transfer functions that model the dynamics of the process. In these functions, the numerator represents the gain factor, which determines how strongly the output signal will respond to a change in the input [4]. The value in the denominator is the Laplace operator s and the time constant. The time constant determines the reaction rate of the system, characterizes the inertia of the process. The following relationship is established: the lower the value of the time constant, the faster the system reacts.

List of literature

1. Saveliev V.A., Ivanov I.M. Modernization of the hydraulic stand ol-10 [Text] // Bulletin of Kurgan State University, 2012 – pp. 11-12.

2. Volkova Yu.S. Economic efficiency of digital transformation of the oil and gas industry [Text] //Mathematical and computer modeling in economics, insurance and risk management, 2023. – No.8. – pp. 210-216.

3. Girgidov A.D. Mechanics of liquid and gas (hydraulics): textbook for universities. – St. Petersburg: Publishing House of SPbGPU, 2007. − 545 p

4. Alperovich I.V. Adaptation of the leakage model from the main oil pipeline [Text] // Transportation and storage of petroleum products and hydrocarbons, 2022. – C. 24-28.