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МОДЕЛЮВАННЯ ТА ДОСЛІДЖЕННЯ РОТОРНОГО ВУЗЛА РОЗРІЗНОГО ГІДРАВЛІЧНОГО КЛЮЧА

В роботі виконано моделювання чотиримасової системи редуктора та дослідження стійкості, модернізованої конструкції розрізного трубного гідравлічного ключа.

Ключові слова: *гідравлічний ключ, роторний вузол гідравлічного ключа, моделювання, графічна модель.*

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MODELING AND RESEARCH OF THE ROTARY ASSEMBLY OF A CUTTING HYDRAULIC WRENCH

The work includes modeling of a four-mass gearbox system and research into the stability of a modernized design of a split pipe hydraulic wrench.

Keywords: *hydraulic wrench, hydraulic wrench rotor assembly, modeling, graphic model.*

Introduction. The analysis of hydraulic wrenches showed that the hydraulic wrench of the Canadian company Farr KT-5500[1] has a wide range of pipe diameters, the most common, and also has a wide range of operating speeds. During the work on the master's thesis, we selected this KT-5500 wrench for research and further modernization.

The KT5500 hydraulic wrench is a hydraulically powered pipe wrench for screwing and unscrewing pipes, with a wide torque range, can handle pipes from 2-1/16 inches to 5-1/2 inches in diameter. Jaw and die tightening technology is available for two pliers. Also available with a CHROMEMASTER “softgrip” clamping unit. The wrench can be mounted on a CLINCHER or FARR hydraulic support.

During the analysis of the wrench design, some shortcomings were identified and these components were modernized with the aim of improvement, namely: replacement of the support rollers of the rotary table, modification of the reversing switching system when turning/turning threaded connections, replacement of the guide rollers of the rotary gear.

Presentation of the main material. The operation of gears is affected by various moments of force. Uneven loads can damage gears, therefore, the study of the gears of the hydraulic wrench and its gearbox design (designed in SolidWorks[2], see Fig. 1) after its modernization is an urgent task.

Figure 1. **Three-dimensional model of the gearbox design**

Making a 3D model of the hydraulic wrench gearbox (Fig. 1) and having given the material of the gears, we know what mass all the gears have, thus, the masses of the bodies m_1=6.78 kg, m_2 =7.91 kg, m_3=7.91 kg, m_4=7.91 kg. The necessary data for modeling the system are given in Table 1.

Table 1.

Input data for system modeling

Damping coefficients, N s/m	Spring stiffness, N/m
h_1=45	c_1=75000
h_2=45	c_2=75000
h_3=35	c_3=55000
h_4=35	c_4=55000
h_5=200	c_5=100000

The simulation of a four-mass system in the Simulink [3, 4] environment is presented in Fig. 2.

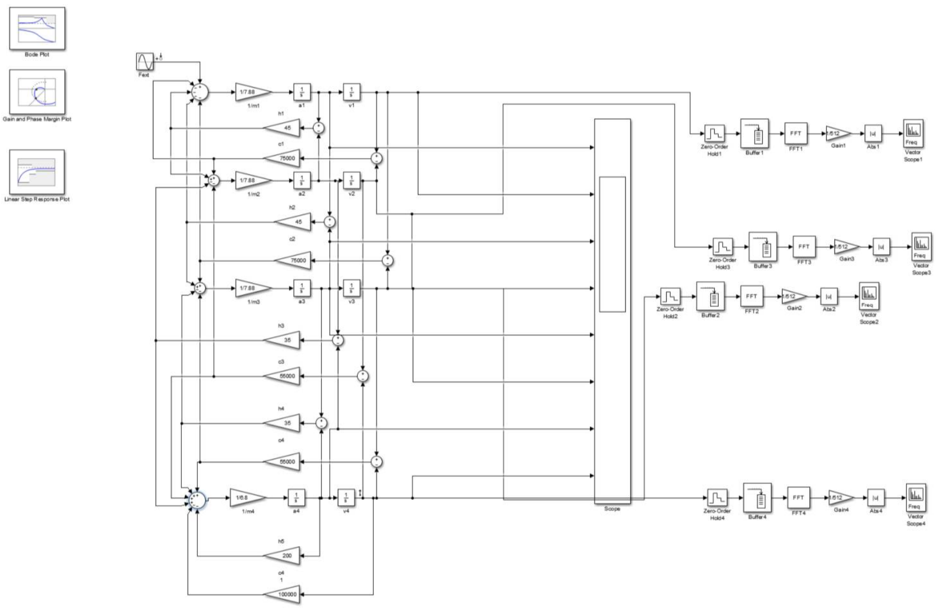


Figure 2. **Graphical model of the structure in the Simulink environment**

After constructing the circuit, we mark the input and output characteristics on it (Fext and x 4 respectively). Using the Scope block , we obtain graphs of the displacement and velocity of all bodies. Using the Zero - Order blocks Hold and Spectrum Analyzer we obtain the frequency spectrum of the system. Using Bode blocks Plot , Linear Step Response Plot , Gain and Phase Margin Plot we obtain graphs of the amplitude-phase frequency characteristics of the system.

As a result, we obtain the following graphs (Fig. 3-4):

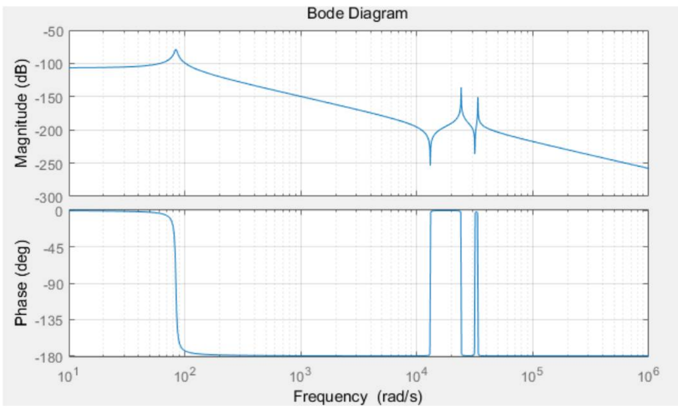
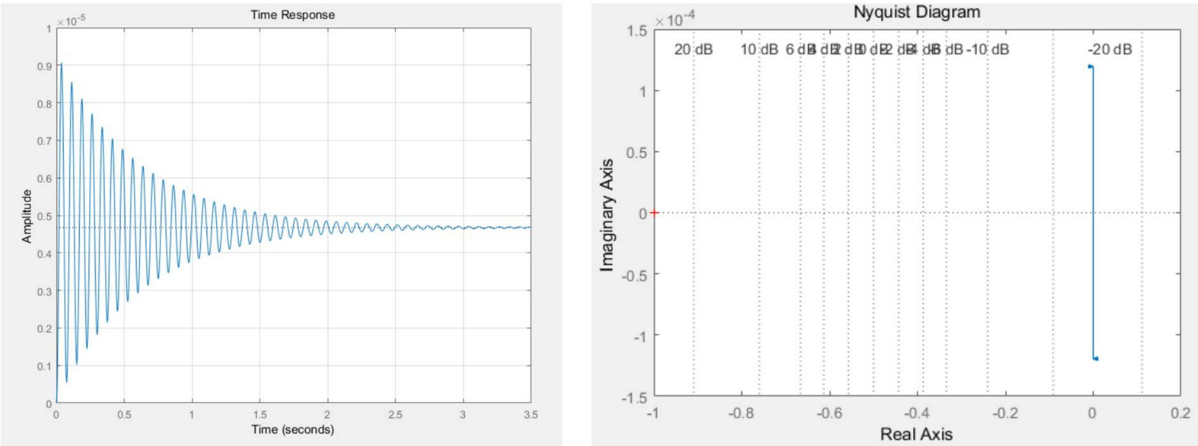


Figure 3. **AFC graph constructed using the command bode (w)**

Conclusions. The step (w) command is responsible for plotting the transient process when a force is applied to the system. The graph shows that the transient process time is 3.5 s. The transient function decays, so the system is stable. It is important to monitor the natural frequencies of the system so that the bodies are not in resonance.



a b

Figure 4. **AFC graph constructed using the command: a) ltiview (w), b) nyquist (w)**

Bode function shows the construction of the logarithmic frequency response. The graph shows that the system is stable because the -180º LAH (logarithmic amplitude-phase frequency response) is negative when the phase response is reached.

Thus, according to the data analysis, the displacement of the entire system is quite small, and the vibration is extinguished within 3.5 seconds. Therefore, the gear system can withstand the additional load.

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