23. Гидравлический модулятор для тормозной системы транспортного средства : пат BY 19812 C1 / М. И. Жилевич, С. В. Ермилов. – Опубл. 28.02.2016

24. Модулятор гидравлического тормозного привода с большим расходом рабочей жидкости / М. И. Жилевич [и др.] // Вестник Харьковского национального автомобильно-дорожного университета : сб. науч. тр. / Харьк. нац. автомоб.-дор. ун-т ; редкол.: В. А. Богомолов (глав. ред.) [и др.]. – Харьков : ХНАДУ, 2016. – Вып. 75. – С. 83–88.

25.. Zhilevich, M., Method of calculating the design parameters of a modulator anti-lock braking system with a high flow of working fluid. / M. Zhilevich, [et al.] // Scientific Journal of Silesian University of Technology. Series Transport. / ed. P. Czech (editor-in-chief) [et al.]. – The Publishing House of the Silestian University of Technology, 2021. – Vol. 110. – P. 199–210.

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MATHEMATICAL MODEL OF THE MODULATOR OF THE BRAKE DRIVE OF A DUMP TRUCK WITH A HYDRAULIC ANTI-LOCK SYSTEM

The use of various methods for obtaining mathematical models can significantly reduce the time for design and research work during the development of hydraulic drives.

Currently, the use of powerful personal computers makes it possible to significantly improve the quality of the results of the mathematical models being developed due to a more detailed description of the processes, determine the structure of the hydraulic drive being developed or its individual elements and select the parameters that have the greatest impact on the dynamic processes occurring in the object under study.

In this paper, a mathematical model of the modulator of the anti-lock braking system of a particularly heavy-duty vehicle, presented in the form of a system with concentrated parameters, is obtained.

The paper also discusses the main methods of compiling mathematical models of hydraulic drives and analyzes the work devoted to the development of various mathematical models that describe the hydraulic drive with varying degrees of accuracy, which makes it possible to choose the most rational way to compile a mathematical model of the modulator of the hydraulic anti-lock braking system of a particularly heavy-duty vehicle, taking into account the assumptions made.

Solving a system of differential equations describing the resulting mathematical model using numerical methods or various specialized software environments, for example, such as Matlab with the Simulink extension, further allows us to investigate the influence of internal parameters on dynamic processes in the proposed hydraulic anti-lock system modulator and select their most optimal values.

Keywords: *mathematical model, modulator, anti-lock system, hydraulic drive, heavy-duty vehicle.*

References

1. Volumetric hydraulic drive and hydropneumoautomatics / Avrunin G. A., [et al.] – Kharkiv: KHNADU, 2008. – 412 p.

2. Bashta, T. M. Machine-building hydraulics / T. M. Bashta. – M.: Mashinostroenie, 1971. – 672 p.

3. Gray, J. Parameter Identification for Electrohydraulic Valvetrain Systems / J. Gray, M. Krstic, N. Chaturvedi // Dynamic Systems, measurement and Control. – 2011. – № 6. – P. 157–162.

4. Mintsa, H .A. Feedback Linearization-Based Position Control of an Electrohydraulic Servo System With Supply Pressure Uncertainty / H. A. Mintsa, R. Venugopal, J. P. Kenne, C. Belleau // IEEE Transactions on Control Systems Technology. – 2012. – N 4. –P. 1092–1099.

5. Ferreira, J. A. Hybrid models for hardware-in-the-loop simulation of hydraulic systems. Part 1: theory /J. A. Ferreira, F. G. Almeida, M. R. Quintas, J. P. Estima de Oliveira // Proceedings of the Institution of Mechanical Engineers, Part I: Journal of Systems and Control Engineering. – 2004. – Vol. 218. – № 6. – P. 465–474.

6. Pohl, J. Modelling and validation of a fast switching valve intended for combustion engine valve trains / J. Pohl, M. Sethson, P. Krus, J. O. Palmberg // Proceedings of the Institution of Mechanical Engineers, Part I: Journal of Systems and Control Engineering. –2002. – Vol. 216. –№. 2. – C. 105–116.

7. Borovin, G. K. Modeling of the dynamics of the hydraulic drive of the foot of a walking machine / G. K. Borovin, A. V. Kostyuk // Preprints of the Institute of Applied Mathematics named after M. Keldysh RAS. – 2002. – pp. 8–28.

8. Borovin, G. K. Modeling of the hydraulic system of the exoskeleton / G. K. Borovin, A. V. Kostyuk, D. Sit, V. V. Yastrebov // Mathematical modeling. – 2006. –№ 10. – pp. 39–54.

9. Aranovsky, S. V. Modeling and identification of the dynamics of a spool hydraulic distributor. Part I. Modeling / S. V. Aranovsky, L. B. Freidovich, L. V. Nikiforova, A. A. Losenkov // Izv. vuzov. Instrumentation. –2013. – Vol. 56. – № 4. – pp. 52–56.

10. Aranovsky, S. V. Modeling and identification of the dynamics of a spool hydraulic distributor. Part II. Identification / S. V. Aranovsky, L. B. Freidovich, L. V. Nikiforova, A. A. Losenkov // Izv. vuzov. Instrumentation. –2013. – Vol. 56. – № 4. – pp. 57–60.

11. Avtushko, V .P. Investigation of the dynamics of the pneumohydraulic brake drive of cars and road trains : abstract. dis. ... Candidate of Technical Sciences : 05.05.03 / V. P. Avtushko ; BPI. – Mn.: 1972. – 23 p.

12. Balakin, V. D. Analytical study of wheel braking with an anti–blocking device / V. D. Balakin, M. A. Petrov // Automotive industry – 1965. – № 11. – pp. 17–20.

13. Bulgakov, N. A. Investigation of the interaction of the car with the road during braking : abstract. dis. ... Candidate of Technical Sciences :

05.05.03 / N. A. Balakin – Kharkiv. auto.-dor. in-t – Kharkiv: 1973. – 28 p.

14. Kapustin, V. V. Study of dynamics and substantiation of parameters of the modulator of the anti–blocking device of the hydraulic brake drive of heavy–duty vehicles : dis. ... Candidate of Technical Sciences: 05.05.03/ V. V. Kapustin. – Minsk, 1977. – 239 p.

15. Metlyuk, N. F. Dynamics of pneumatic and hydraulic drives of cars / N. F. Metlyuk, V. P. Avtushko – M. : Mashinostroenie, 1980. – 231 p.

16. Levitsky, N. I. Calculation of control devices for braking hydraulic drives / N. I. Levitsky, E. A. Tsukhanova – M.: Mashinostroenie, 1971. – 321 p.

17. Vibrations of elements of axial piston hydraulic machines / K. V. Frolov [et al.]; edited by K. V. Frolov. – M.: Mechanical Engineering, 1973. – 280 p.

18. Kondakov, L. A. working fluids and seals of hydraulic systems / L. A. Kondakov. – M.: Mechanical Engineering, 1982. – 216 p.

19. Fluidon [Electronic resource]. – Access mode: https://fluidon.com/en – Access date: 22.09.2023.

20. Simulink [Electronic resource]. – Access mode: https://www.mathworks.com/products/simulink.html – Access date: 22.09.2023.

21. HydroCad [Electronic resource]. – Access mode: https://www.hydrocad.net / – Access date: 22.09.2023.

22. Zhilevich, M. I. Substantiation of the parameters of the integrated diagnostics system of the combined hydraulic drive to improve the safety and efficiency of BelAZ dump trucks : dis. ... Candidate of Technical Sciences : 05.05.03 / M. I. Zhilevich; BNTU – Minsk, 2006. – 249 p.

23. Hydraulic modulator for vehicle braking system : pat BY 19812 C1 / M. I. Zhilevich, S. V. Ermilov. – Publ. 02/28/2016

24. Modulator of a hydraulic brake drive with a large flow of working fluid / M. I. Zhilevich [et al.] // Bulletin of the Kharkiv National Automobile and Road University : collection of scientific tr. / Kharkiv. nats. auto.-dor. un-t ; editorial board.: Bogomolov V. A. (glav. ed.) [et al.]. – Kharkiv: KHNADU, 2016. – Issue 75. – pp. 83–88.