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Improved mathematical model of the operation of hydraulic drives of garbage truck mounted sweeping equipment with regard to the wear of a cylindrical brush

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Abstract

The article is dedicated to the improvement of the mathematical model of operation of hydraulic drives of mounted sweeping equipment of a garbage truck, taking into account the wear of a cylindrical brush. An improved nonlinear mathematical model of the operation of hydraulic drives of mounted sweeping equipment of a garbage truck that takes into account the wear of a cylindrical brush, is proposed, which allowed to numerically study the dynamics of these drives during startup and determine that taking into account the wear of the cylindrical brush significantly affects such values as the pressure at the inlet of the hydraulic motor of the cylindrical brush and the angular velocities of both hydraulic motors. At the same time, the pressure at the inlet of the screw conveyor hydraulic motor after taking into account the wear of the cylindrical brush has hardly changed. The study of this mathematical model was carried out using the numerical Runge-Kutta-Felberg method of the 4th order with a variable integration step. It was also established the graphical dependencies to compare changes in the main parameters of the hydraulic drive of the garbage truck's mounted sweeping equipment during startup without taking into account the wear of the cylindrical brush and with taking into account the wear. It has been established that the creation of a linearized mathematical model of the operation of hydraulic drives of garbage truck mounted sweeping equipment, taking into account the wear of a cylindrical brush, and its analytical solution in order to obtain dependencies for an improved methodology for engineering calculations require further research.

Keywords: wear, mathematical model, rotational speed, mounted sweeping equipment, cylindrical brush, garbage truck.

Introduction

Increasing the wear resistance, durability, and reliability of machine parts is one of the key tasks of the Ukrainian machine-building industry, especially for municipal sweeping machines [1, 2]. Municipal vehicles equipped with brushing equipment are widely used to clean the road surface from contaminants. The most common is brushing equipment with cylindrical brushes, the pile of which is made of polymeric material. During operation, the bristles of a cylindrical brush wear out intensively due to interaction with the working surface containing abrasive particles. This leads to changes in its elastic properties. To maintain the optimum width of the contact patch, the force of pressing the brush against the road surface is increased. This approach ensures high quality road surface cleaning and minimizes the intensity of pile wear. An analysis of statistical data showed that the level of wear and tear of the vehicle fleet of Khmelnytskyi region's municipal enterprises decreased slightly from 63% to 59% between 2015 and 2020, despite the measures taken [3, 4]. According to the Resolution of the Cabinet of Ministers of Ukraine No. 265 [5], one of the priority tasks is to provide the country's utilities with modern and highly efficient garbage trucks, which play a key role in the processes of collection, transportation and primary processing of municipal solid waste (MSW). This task is facilitated, in particular, by expanding the functionality of the garbage truck by equipping it with mounted sweeping equipment. This approach generally helps to improve the overall reliability of utility companies' operations, while simultaneously solving a number of environmental issues. Planning for the improvement, renewal, maintenance, and repair of municipal equipment is facilitated by improving the mathematical model of the operation of hydraulic drives of the garbage truck's mounted sweeping equipment, taking into account the wear of the cylindrical brush.

Analysis of recent research and publications

Article [6] describes measures aimed at significantly improving the efficiency of the technological process of cleaning of road's pavement. These measures are aimed at reducing the need for cleaning equipment and manual labor, as well as improving the sanitary, hygienic, aesthetic, transport and operational condition of the road surface within urban areas. It is noted that the elastic modulus of the pavement of intra-quarter passages should be at least 125 MPa, while for sidewalks and pedestrian alleys over 3 meters wide – should not exceed 85 MPa. If the moisture content of the garbage is up to 20%, it is recommended to use sweeping machines with additional moistening of the garbage to a level of less than 15%. If the moisture content of the garbage exceeds 20%, it is advisable to use water washers.

The work [7] considers the technology for maintaining the city's street and road network during the period with positive air temperatures, describes methods for planning and determining the volume of cleaning work, provides technical characteristics of sweeping machines, and presents a method for calculating their required number. The characteristics and composition of garbage on the roadway of city streets and roads are presented, including its fractional distribution, the content of dusty particles by fraction in the air above the road surface, the concentration of the main and most harmful components of road dust, seasonal changes in the composition of garbage, as well as the estimated annual accumulation of street garbage per 1 m^2 of road surface for cities. It was also identified the key factors that affecting the performance of street sweeping machines during the cleaning of the city's road network. The paper considers the productivity of sweeping machines, analyzes the factors that affect its level, and presents a methodology for calculating productivity. The modes (frequency) of road surface cleaning, the intensity of garbage accumulation on its surface, and the level of contamination depending on the intensity of traffic are also determined.

The paper [8] considers the results of analyzing a set of partial indicators, including fuel consumption during operation, work performance, maintenance and repair costs of brush equipment, and the cost of cleaning a certain area of roads or urban areas. These indicators make it possible to assess the efficiency of operation of municipal sweeping machines equipped with brush equipment. The study presents a functional scheme for the formation of a generalized efficiency criterion and proposes a mathematical expression for its calculation. In addition, an expression for determining a generalized criterion for the efficiency of using municipal machines based on the selected aggregation function. The paper proposes a functional scheme for the formation of a generalized efficiency criterion that provides a visual representation of the relationships between the factors that influence the partial indicators of efficiency of the use of municipal sweeping machines.

The article [9] presents a study that was carried out by modeling brushes using the finite element analysis method to develop a system for automating the road sweeping process. Taking into account the type of garbage and road conditions, it is noted that the driver of a sweeping machine needs to adjust the vertical pressure, angle of inclination, and speed of rotation of the curb brush, as well as regularly monitor the quality of sweeping. The driver's work is complicated by the need to simultaneously carefully control the machine and perform sweeping operations. Previously, achieving efficient road sweeping has been difficult, partly due to a lack of knowledge about the basic characteristics of sweeping brushes. The study uses a finite element model to analyze the deformation of metal brushes as they are pressed and rotated on the road surface. The main parameters considered include the length, width, and thickness of the teeth, the radius of their installation, the angle of installation, and the orientation of the teeth, as well as the number of teeth in a cluster, the number of clusters in a row, and the number of rows. The brush teeth were modeled as thin cantilever beams using the commercial software package FE ANSYS. This model was used to obtain the key characteristics of the brush, including the force-strain relationship, contact pattern, and torque. The effect of different tooth geometries on brush performance was also analyzed.

The research paper [10] states that the use of brush seals can increase engine performance by reducing losses. Brush seal wear models offer methods for predicting the level of wear and associated costs. However, existing models do not systematically take into account rotor eccentricity, radial deformation, and the effect of bristle hysteresis, which can lead to significant errors in certain situations. To study the effect of rotor-stator eccentricity and radial deformation on the wear process and flow characteristics of the brush seal, experimental tests were carried out. During the tests, the air leakage rate was measured under different operating conditions and at different moments in time, while the eccentricity and radial deformation were determined using eddy current sensors. The test results showed that eccentricity and radial deformation significantly affect the wear process and cost efficiency. In the theoretical study, the abrasive wear equation was used to describe the loss of pile material, while the eccentric rotor-stator motions were described using a simplified model. A wear model for the brush seal was developed taking into account the rotor-stator eccentricity and radial deformation, which especially takes into account the hysteresis effect. The developed model was verified on the basis of experimental data from brush seal tests. The results showed that when the rotor eccentricity, radial deformation, and hysteresis effect are fully taken into account, the error is 20% compared to the calculated wear losses.

The paper [11] consider the interaction of forces and temperature effects on friction and wear of the brush pile, and also determine the quantitative characteristics that affect the service life and efficiency of the sweeping process depending on the properties of the removed contaminants and operating modes. The developed and implemented on a PC simulation model of the functioning of the brush unit of a municipal sweeping machine provides forecasting of the process characteristics and identification of cause-and-effect relationships between the brush parameters and operating modes. The simulation model makes it possible to predict the service life and performance of the brush at the early stages of designing the brush body of a municipal machine, taking into account the model conditions of further use. The parametric adjustment of the simulation model was carried out by matching the calculated and experimental values of brush pile wear obtained in the experiment conditions. The criteria characterizing the intensity of brush lint wear were established. It is found out that the main factors that impede the establishment of optimal operating modes of municipal machines are the limitation of the brush rotation frequency and the heating of the contact surface of the pile, which leads to a deterioration in the mechanical properties of the pile material and an increase in the intensity of its wear.

The scientific article [12] considers the problem of improving the quality of road surface cleaning and extending the service life of brushing equipment. Improving the quality of cleaning and increasing the service life of brushing equipment will help reduce the cost of operating municipal equipment. During operation, the pile of a cylindrical brush is subject to wear, which leads to a change in its elastic properties. This makes it necessary to apply the optimal clamping force to maintain a rational width of the contact patch, which ensures high quality cleaning and minimizes pile wear. The article presents the dependence of the degree of wear of the brush pile of brush working equipment on the actual radius of the cylindrical brush. The influence of the degree of wear on the elastic properties of the brush working equipment is also analyzed. The dependence of the average stiffness coefficient on the degree of wear of the cylindrical brush bristles is given, as well as the dependence of the required clamping force on the degree of wear at different values of the width of the contact patch of the cylindrical brush. The dependence of the pressure in the hydropneumatic accumulator of the brush working body position control device on the actual free length of the cylindrical brush bristles was also determined.

Paper [13] presents a nonlinear mathematical model that describes the operation of hydraulic drives of the working bodies of the garbage truck's mounted sweeping equipment in the form of a system of differential equations, as well as the results of its numerical and analytical study. However, this mathematical model does not take into account the wear of the cylindrical brush.

Scientific publication [14] is dedicated to determining the power law of the wear of a cylindrical brush of the mounted sweeping equipment of a garbage truck depending on its rotation frequency. It has been established that for a Ukrainian-made sweeping machine of the serial model KO-713-01 that is equipped with a cylindrical brush with a rotation speed of 3200 rpm, its wear according to the obtained dependence will reach 86.5 mm. It has been also found that reducing the rotational speed of the cylindrical brush of the garbage truck's mounted sweeping equipment from 62 sec^{-1} (3700 rpm) to 26...38 sec^{-1} (1550...2250 rpm) leads to a decrease in its wear by 2 orders of magnitude.

In the article [15], adequate regularities according to the Fisher criterion were established, which describe the effect of cylindrical brush wear on the performance characteristics of the garbage truck's mounted sweeping equipment. It has been established that, according to the Student's criterion, the degree of wear of a cylindrical brush has the greatest influence on the value of deformation of the brush, while the least influence has the width of the contact patch. It has been determined that the the required clamping force of a cylindrical brush is most influenced by the width of the contact patch, while the degree of its wear has the least influence. The response surfaces of the objective functions are demonstrated – the values of deformation and the required clamping force of the cylindrical brush, and their two-dimensional sections in the planes of the influence parameters, which clearly illustrate the dependence of these objective functions on individual parameters. It was determined that at a wear rate of 50%, the value of the cylindrical brush deformation increases by 1.3 times, while the required clamping force increases by 3.1-3.6 times, depending on the width of the contact patch.

However, as a result of the analysis of known publications, the authors did not find a specific mathematical model describing the operation of hydraulic drives of the working bodies of the garbage truck's mounted sweeping equipment, taking into account the wear of the cylindrical brush.

However, as a result of the analysis of known publications, the authors did not find a specific mathematical model that describes the operation of the hydraulic drives of the working bodies of the attached sweeping equipment of a garbage truck, taking into account the wear of the cylindrical brush.

Aims of the article

Improvement of the mathematical model of the operation of hydraulic drives of the mounted sweeping equipment of a garbage truck, taking into account the wear of a cylindrical brush.

Methods

Fig. 1 shows the scheme of the garbage truck operation during the sweeping operation [13], which indicates the following structural elements and parameters: GM_1, GM_2 – hydraulic motors, TR– throttle, H– hydraulic pump, SV– safety valve, F– filter, FT– working fluid tank. The scheme also shows the following basic geometric, kinematic and power parameters: p_1, p_2, p_3, p_4– respectively: pressures at the outlet H, at the inlet GM_1, at the inlet GM_2, at the outlet GM_2; W_1, W_2, W_3, W_4– volumes of pipelines between H and TR, TR and GM_1, GM_1 and GM_2, GM_2 and F; Q_H – actual flow rate of H; S_{TR} – the area of inlet of TR; S_F – is the surface area of the filter element F; q_{M1}, q_{M2} – the working volumes of GM_1, GM_2; J_1, J_2 – the of inertia moments of the shafts of GM_1, GM_2; M_{T1}, M_{T2} – torques of technological load on shafts of GM_1, GM_2 ; ω_1, ω_2 – angular velocities of shafts GM_1, GM_2 .

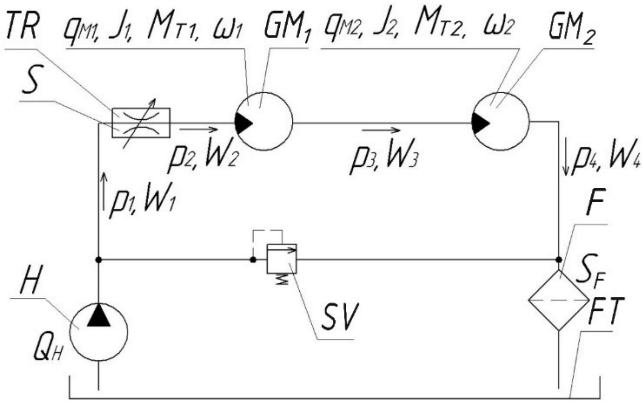

Fig. 1. Scheme of operation of a garbage truck during sweeping

The technological operation of sweeping can be described by the corresponding system of nonlinear differential equations (1-6) with the corresponding boundary conditions (7) and algebraic equation (8) [13]:

$$Q_H = \mu S_{TR}\sqrt{\frac{2(p_1-p_2)}{\rho}} + \sigma(p_1-p_2) + KW_1\frac{dp_1}{dt}; \quad (1)$$

$$\mu S_{TR}\sqrt{\frac{2(p_1-p_2)}{\rho}} = q_{MX1}\omega_1 + \sigma(p_2-p_3) + KW_2\frac{dp_2}{dt}; \quad (2)$$

$$q_{MX1}\omega_1 = q_{MX2}\omega_2 + \sigma(p_3-p_4) + KW_3\frac{dp_3}{dt}; \quad (3)$$

$$q_{MX2}\omega_2 = k_F\frac{p_4}{\mu_Д}S_F + \sigma p_4 + KW_4\frac{dp_4}{dt}; \quad (4)$$

$$q_{MX1}(p_2-p_3) = J_1\frac{d\omega_1}{dt} + \beta\omega_1 + \alpha q_{MX1}(p_2+p_3) + \frac{\pi^3 r_B^3 S^6 E B_M f_B (S+R_Б-h)K_R K_U \sin\gamma}{384{,}3\, y_K^8 \eta_B}; \quad (5)$$

$$q_{MX2}(p_3-p_4) = J_2\frac{d\omega_2}{dt} + \beta\omega_2 + \alpha q_{MX2}(p_3+p_4) + \frac{3{,}343\pi^2 (q_m B_M v_M)^{1,4} l_K f_K^{1,2}}{[\psi(1-\beta/50)]^{1,4}\rho_s^{0,4}[g\cdot tg(\alpha-\beta+arctg\, f_g)]^{0,2}}; \quad (6)$$

$$0 \le \{p_1, p_2, p_3, p_4\} \le p_s;\ 0 \le \{\omega_1, \omega_2\}; \quad (7)$$

$$q_{MX} = q_M/2\pi, \quad (8)$$

where r_B – the radius of the cross-section of the pile bar, m; S = 70...160 mm – the free length of the pile, mm; E – the modulus of elasticity of the brush pile material, MPa; B_M – the width of the sweeping strip, m; f_B – the coefficient of friction of the brush pile material on the road surface; R_D – the radius drum of the cylindrical brush, mm; h – the value of brush pile deformation, mm; K_R = 1.1 – the coefficient of power reserve for overcoming inertial forces in an unstated mode of movement, pile deformation forces, and aerodynamic resistance; K_U = 2...2.5 – coefficient of unevenness of the pile arrangement on the generating surface of the brush drum; γ – pile inclination angle, deg; y_K – distance between the drum rim and the horizontal surface of the road, mm; η_B – efficiency of the drive of cylindrical brush; q_m = 0.1 kg/m^2 – amount of contamination per unit area of the road surface, kg/m^2; v_M = 0.7...6 m/sec – operating speed of the machine during sweeping, m/sec; ψ = 0.125– filling factor; β – angle of inclination of the screw conveyor, deg; l_S – length of the screw conveyor, m; f_K – friction coefficient of the particle on the conveyor casing; ρ_s = 1.4· 10^3 kg/m^3 – density of the swept waste; g = 9.8 m/sec^2 – free fall acceleration, m/sec^2; α – angle of rise of the screw line, deg; f_g – coefficient of friction of the particle on the conveyor screw.

In the paper [14] it was determined the dependence of wear of the cylindrical brush of the mounted sweeping equipment of a garbage truck depending on its rotation frequency:

$$u = 0{,}4593 + 1{,}834\cdot 10^{-8} n^{5,6} = 0{,}4593 + 1{,}834\cdot 10^{-8}\left(\frac{\omega_1}{2\pi}\right)^{5,6} = 0{,}4593 + 6{,}217\cdot 10^{-13}\omega_1^{5,6} \text{ [mm]}, \quad (9)$$

where u – the wear of the cylindrical brush, mm; n – rotational speed of the cylindrical brush, sec^{-1}.

The dependence of the effect of cylindrical brush wear on the value of its deformation for different widths of the contact patch was determined in the work [15].

$$h = \Delta Y_{CB} = 0{,}002832 X_k - 0{,}04836 C_u + 6{,}822\cdot 10^{-4} C_u\, X_k + 1{,}674\cdot 10^{-4} C_u^2 + 4{,}297\cdot 10^{-4} X_k^2, \quad (10)$$

where ΔY_{CB} – the deformation value of the cylindrical brush, mm; C_u – the degree of wear of the cylindrical brush, %; X_k – the width of the contact patch, mm.

To study an improved nonlinear mathematical model of the operation of hydraulic drives of garbage truck mounted sweeping equipment, taking into account the wear of a cylindrical brush in the form of a system of ordinary nonlinear differential equations with appropriate boundary conditions, the Runge-Kutta-Felberg numerical method of the 4th order was used with a variable integration step.

Results

The free length of the pile, taking into account its wear, can be determined by the following formula:

$$S = S_0 - u \text{ [mm]}, \quad (11)$$

where S_0 – the initial free length of the pile, mm.

The degree of wear of the cylindrical brush wear can be determined by the formula:

$$C_u = \frac{u}{S_0} 100\%. \quad (12)$$

After substituting formulas (9)–(12) into the equation (5), the improved nonlinear mathematical model of the operation of hydraulic drives of the garbage truck's mounted sweeping equipment, taking into account the wear of the cylindrical brush, can be written as follows:

$$\begin{cases}
Q_H = \mu S_{TR}\sqrt{\frac{2(p_1 - p_2)}{\rho}} + \sigma(p_1 - p_2) + KW_1\frac{dp_1}{dt}; & (13)\\
\mu S_{TR}\sqrt{\frac{2(p_1 - p_2)}{\rho}} = q_{MX1}\omega_1 + \sigma(p_2 - p_3) + KW_2\frac{dp_2}{dt}; & (14)\\
q_{MX1}\omega_1 = q_{MX2}\omega_2 + \sigma(p_3 - p_4) + KW_3\frac{dp_3}{dt}; & (15)\\
q_{MX2}\omega_2 = k_F\frac{p_4}{\mu_D}S_F + \sigma p_4 + KW_4\frac{dp_4}{dt}; & (16)\\
q_{MX1}(p_2 - p_3) = J_1\frac{d\omega_1}{dt} + \beta\omega_1 + \alpha q_{MX1}(p_2 + p_3) + \frac{\left(S_0 - 4{,}593\cdot 10^{-4} - 6{,}217\cdot 10^{-16}\omega_1^{5,6}\right)^6}{384{,}3 y_K^8 \eta_B}\times & \\
\times \pi^3 r_B^3 E B_M f_B K_R K_U \sin\gamma\Big[S_0 + R_D - 2{,}832\cdot 10^{-6} X_k - 4{,}297\cdot 10^{-7} X_k^2 - \big(4{,}593\cdot 10^{-4} + & (17)\\
+ 6{,}217\cdot 10^{-16}\omega_1^{5,6}\big)\left(1 + \frac{6{,}822\cdot 10^{-5} X_k - 4{,}836\cdot 10^{-3}}{S_0}\right) - \frac{\left(5{,}943\cdot 10^{-4} + 8{,}044\cdot 10^{-16}\omega_1^{5,6}\right)^2}{S_0^2}\Big]; & \\
q_{MX2}(p_3 - p_4) = J_2\frac{d\omega_2}{dt} + \beta\omega_2 + \alpha q_{MX2}(p_3 + p_4) + \frac{3{,}343\pi^2\left(q_m B_M v_M\right)^{1,4} l_B f_K^{1,2}}{\left[\psi(1 - \beta/50)\right]^{1,4}\rho_s^{0,4}\left[g\cdot tg\left(\alpha - \beta + arctg\, f_g\right)\right]^{0,2}}; & (18)\\
0 \le \{p_1, p_2, p_3, p_4\} \le p_s;\ 0 \le \{\omega_1, \omega_2\}; & (19)
\end{cases}$$

$$q_{MX} = \frac{q_M}{2\pi}. \quad (20)$$

A comparison of the change in the main parameters of the hydraulic drive of the garbage truck's mounted sweeping equipment during startup without taking into account the wear of the cylindrical brush and with taking into account the wear is shown in the Fig. 2. The graphical dependencies shown in the Fig. 2 were obtained for the following parameters: $Q_H = 1.917 \cdot 10^{-3}$ m^3/sec; $q_{MX1} = 1.432 \cdot 10^{-5}$ m^3/rad; $q_{MX2} = 1.003 \cdot 10^{-4}$ m^3/rad; $M_{T1} = 8.3$ N·m; $M_{T2} = 261$ N·m; $J_1 = 1.98 \cdot 10^{-2}$ kg· m^2; $J_2 = 3.13 \cdot 10^{-2}$ kg· m^2; $W_1 = 1.48 \cdot 10^{-3}$ m^3; $W_2 = W_3 = 5 \cdot 10^{-4}$ m^3; $W_4 = 1 \cdot 10^{-3}$ m^3; $K = 10^{-9}$ Pa; $\sigma = 9.24 \cdot 10^{-11}$ m^5/(N· sec); $S_{TR} = 58$ mm^2.

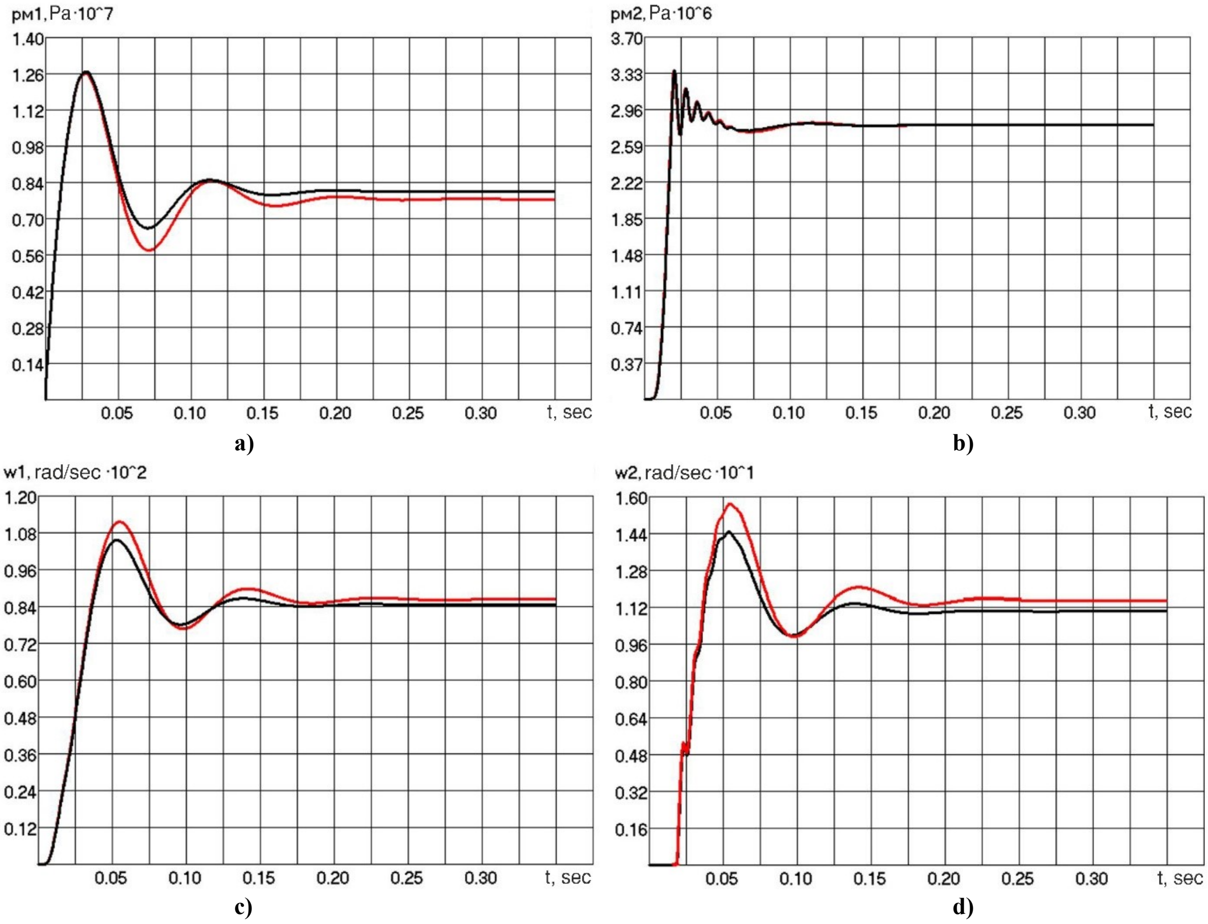

Fig. 2. Comparison of changes in parameters of the hydraulic drive of the garbage truck's sweeping equipment during startup without taking into account the wear of the cylindrical brush (—) and with wear (—): a) inlet pressure of the hydraulic motor GM$_1$; b) pressure of the inlet hydraulic motor GM$_2$; c) angular velocity of the hydraulic motor GM$_1$; d) angular velocity of the hydraulic motor GM$_2$

As it can be seen from the Fig. 2, taking into account the wear of the cylindrical brush in the improved mathematical model significantly affects on such values as the inlet pressure of the hydraulic motor GM$_1$ and the angular velocities of both hydraulic motors. At the same time, the inlet pressure of the hydraulic motor GM$_2$ after taking into account the wear of the cylindrical brush has hardly changed.

Thus, the creation of a linearized mathematical model of the operation of hydraulic drives of garbage truck mounted sweeping equipment, taking into account the wear of a cylindrical brush, and its analytical solution in order to obtain dependencies for an improved methodology of engineering calculations, require further research.

Conclusions

An improved nonlinear mathematical model of the operation of hydraulic drives of mounted sweeping equipment of a garbage truck is proposed, which takes into account the wear of a cylindrical brush and allows to numerically study the dynamics of these drives during startup. It enabled to determine that taking into account the wear of the cylindrical brush significantly affects such values as the pressure at the inlet of the hydraulic motor of the cylindrical brush and the angular velocities of both hydraulic motors. At the same time, the pressure at the inlet of the screw conveyor hydraulic motor after taking into account the wear of the cylindrical brush has hardly changed. The graphical dependencies were established to compare changes in the main parameters of the hydraulic drive of the garbage truck's mounted sweeping equipment during startup without taking into account the wear of the cylindrical brush and with taking into account the wear. It was also established that it needs further research of a linearized mathematical model's creation of hydraulic drives operation of garbage truck mounted sweeping equipment, taking into account the wear of a cylindrical brush, and its analytical solution in order to obtain dependencies for an improved methodology for engineering calculations.

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Березюк О.В., Савуляк В.І., Харжевський В.О., Гарбуз Є.С. Удосконалена математична модель роботи гідроприводів навісного підмітального обладнання сміттєвоза із урахуванням зносу циліндричної щітки.

Стаття присвячена удосконаленню математичної моделі роботи гідроприводів навісного підмітального обладнання сміттєвоза із урахуванням зносу циліндричної щітки. Запропонована удосконалена нелінійна математична модель роботи гідроприводів навісного підмітального обладнання сміттєвоза, яка враховує знос циліндричної щітки і дозволила чисельно дослідити динаміку даних приводів під час пуску та визначити, що врахування зносу циліндричної щітки суттєво впливає на такі величини, як тиск на вході гідромотора циліндричної щітки та кутові швидкості обох гідромоторів. В той же час, тиск на вході гідромотора шнекового транспортера після врахування зносу циліндричної щітки майже не змінився. Дослідження даної математичної моделі проводилось за допомогою чисельного методу Рунге-Кутта-Фельберга 4-го порядку зі змінним кроком інтегрування. Побудовано графічні залежності для порівняння зміни основних параметрів гідроприводу навісного підмітального обладнання сміттєвоза під час пуску без урахування зносу циліндричної щітки та з урахуванням зносу. Встановлено, що побудова лінеаризованої математичної моделі роботи гідроприводів навісного підмітального обладнання сміттєвоза із урахуванням зносу циліндричної щітки та її аналітичне розв'язання з метою отримання залежностей для удосконаленої методики інженерних розрахунків вимагають проведення подальших досліджень.

Ключові слова: знос, математична модель, частота обертання, навісне підмітальне обладнання, циліндрична щітка, сміттєвоз.