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Identify effective STRUKTURYPOSIVNOHO tractor units

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The paper identified the effective structure of sowing tractor unit due to the mathematical model study its dynamics. The results of the calculation speeds elements seed unit and the deviation from the straight trajectory.
Mathematical model of dynamics, tractor, tank, drill.

Formulation of the problem. Farm tractor units are multi-mobile machines. Combined seeding machines consist of three elements, such as a tractor, tank seed drills and moving consecutively. [1] The basic layout scheme of sowing units in which capacity and drill locations can change the sequence [2] or tank seed may be on the tractor and be rigidly connected to it. The dynamics of these multiple machines is not enough research.

Analysis of recent publications. To study the dynamics of multiple machine-tractor units used D'Alembert-Lagrange principle [3] or Lagrange equation of the 2nd kind [4]. There [5] in which the movement of the mobile machine with study vehicle using Lagrange equations of the 1st kind. Question sowing block units depending on its design studied in [2].

The purpose of research: theoretical study of mathematical model of spatial dynamics combined multielement tractor unit.

Research results. In the fields of Ukraine combined widespread crop tractor units production John Deere (Fig. 1).

Fig. 1. Combined seeding machine-tractor unit John Deere 8345R + John Deere 1890+ John Deere 1910.
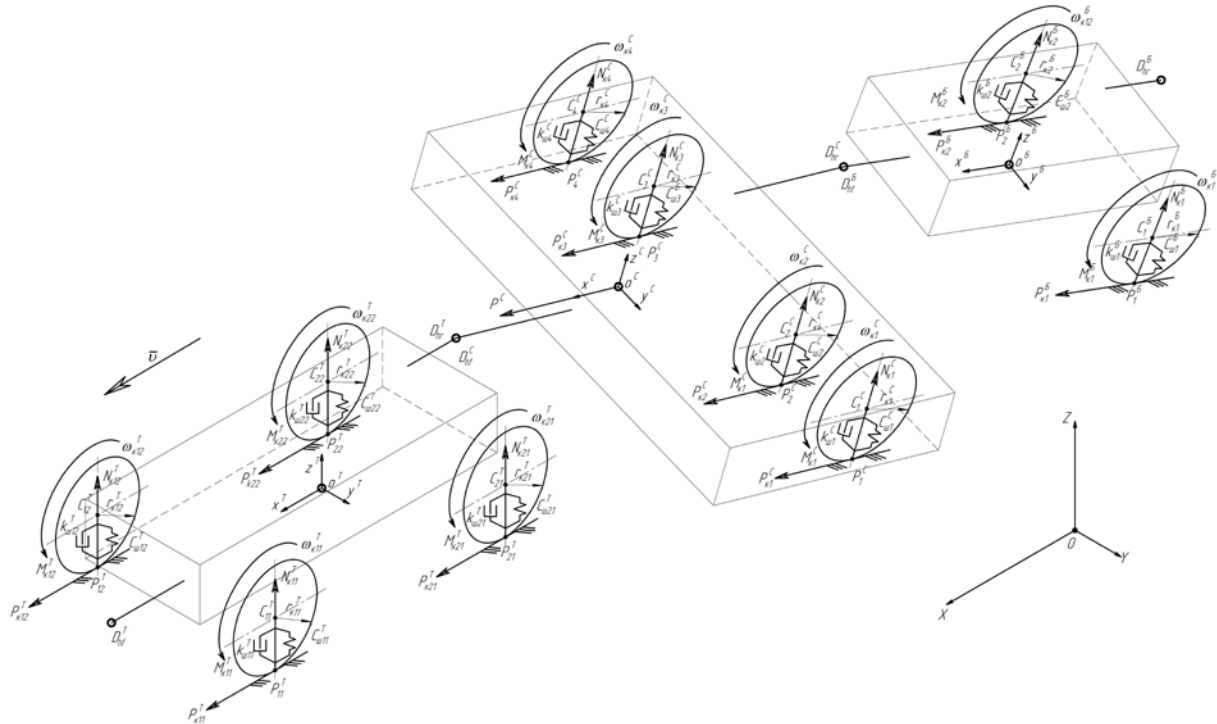

Fig. 2. Dynamic model combined multielement tractor unit.

The choice of the optimal mode of movement and aggregation allows the study of their dynamics. To solve this problem, consider the spatial dynamic model combined sowing tractor unit, which is shown in Fig. 2 and use the following notation: n - Upper index that takes values $T, Б, C$ and indicates affiliation variable element unit, respectively tractor, hopper, sivaltsi; $XOYZ$ - Global coordinate system; $xoyz^n$ - Bound coordinate system; t. o^n - The center of mass; t. O - The center of the global coordinate system; α, β, γ^n - Model angles around respective axes x, y, z; m^n - Mass element unit; J_x^n, J_y^n, J_z^n - Presented to the respective moments of inertia for axes; $\bar{\upsilon}$ - Forward speed of movement; D_{hf}^n, D_{hr}^n - Front and rear seats sample (accession process equipment; $P\kappa_{ij}^n, M\kappa_{ij}^n, N\kappa_{ij}^n$ - Tangential thrust, moment and normal reaction to the respective wheel unit; $Cш_{ij}^n, kш_{ij}^n$ - Given the stiffness and compliance elements tire unit. For the numerical integration of the system of total differential equations consider algorithms for their transformation to the normal form of Cauchy in generalized coordinates or psevdokoordynatah [6]. For holonomnyh introduce vectors of generalized acceleration and velocity - $\mathbf{w} = \dot{\mathbf{v}} = \ddot{\mathbf{q}}, \mathbf{v} = \dot{\mathbf{q}}$ and is written as:

$$\mathbf{Mw} = \mathbf{F},\tag{1}$$

where: $\mathbf{M} = \sum_{i=1}^{n}\left\{\mathbf{W}_{C_i}^{T} m_i \mathbf{W}_{C_i} + \mathbf{W}_{\omega_i}^{T}\left[\vec{J}_i\right]\mathbf{W}_{\omega_i}\right\}$ - Inertia matrix system, $\mathbf{F}$ - Vector-matrix system of generalized forces except in terms of inertial members left side containing no generalized acceleration, which can be obtained by substituting in the equations of motion of analytical expressions are zero psevdopryskorennya and took the result with the opposite sign, that is [6]:

$$\mathbf{F} = -\mathbf{U}\big|_{\ddot{\pi}=0}.$$

After solving system (1) on the generalized acceleration - $\mathbf{w} = \mathbf{M}^{-1}\mathbf{F}$ Finally we get SZDU in the form of the Cauchy problem for nonholonomic systems:

$$\begin{cases}\dot{\mathbf{q}} = \mathbf{Gv} + \mathbf{g} \\ \dot{\mathbf{v}} = \mathbf{M}^{-1}\mathbf{F}\end{cases}.\tag{2}$$

The initial conditions for the system are important independent generalized coordinates and generalized velocities (psevdoshvydkostey) at the initial time:

$$\mathbf{q}\big|_{t=0} = \mathbf{q}_0, \qquad \boldsymbol{\pi}\big|_{t=0} = \boldsymbol{\pi}_0.$$

Dynamic model combined multielement tractor unit (Fig. 2) has eight generalized coordinates, ie eight degrees of freedom:

$$\dot{\mathbf{q}} = \left[X^{T}, Y^{T}, Z^{T}, \beta^{T}, \alpha^{C}, \beta^{C}, \alpha^{Б}, \beta^{Б}\right]^{T}.\tag{3}$$

As an independent coordinate with dependent variations selected:

$$\dot{\mathbf{v}} = \left[\alpha^{T}, \gamma^{T}, \varphi_{11}^{T}, \varphi_{12}^{T}, \varphi_{21}^{T}, \varphi_{22}^{T}, \gamma^{C}, \varphi_{1}^{C}, \varphi_{2}^{C}, \varphi_{3}^{C}, \varphi_{4}^{C} \cdot \gamma^{Б}, \varphi_{11}^{Б}, \varphi_{12}^{Б}\right]^{T}.\tag{4}$$

Mathematical model of the multielement MTA is:

$$\begin{cases}\dot{X}^{T} = f_1(\mathbf{G}, \mathbf{g}, \mathbf{M}, \mathbf{F}); \\ \dot{Y}^{T} = f_2(\mathbf{G}, \mathbf{g}, \mathbf{M}, \mathbf{F}); \\ \dot{Z}^{T} = f_3(\mathbf{G}, \mathbf{g}, \mathbf{M}, \mathbf{F}); \\ \dot{\beta}^{T} = f_4(\mathbf{G}, \mathbf{g}, \mathbf{M}, \mathbf{F}); \\ \dot{\alpha}^{C} = f_5(\mathbf{G}, \mathbf{g}, \mathbf{M}, \mathbf{F}); \\ \dot{\beta}^{C} = f_6(\mathbf{G}, \mathbf{g}, \mathbf{M}, \mathbf{F}); \\ \dot{\alpha}^{Б} = f_7(\mathbf{G}, \mathbf{g}, \mathbf{M}, \mathbf{F}); \\ \dot{\beta}^{Б} = f_8(\mathbf{G}, \mathbf{g}, \mathbf{M}, \mathbf{F}),\end{cases}\tag{5}$$

where: f_i - Function of vector-matrix $\mathbf{G}, \mathbf{g}, \mathbf{M}, \mathbf{F}$; $i = 1,...,8$ - Serial number of generalized coordinates.

Equation independent coordinate with dependent variations are as follows:

$$\begin{cases} \dot{\alpha}^{\mathrm{T}} = \dfrac{a^{\mathrm{T}}\dot{X}^{\mathrm{T}} + b^{\mathrm{T}}\dot{Y}^{\mathrm{T}} + c\dot{Z}^{\mathrm{T}} - \beta^{\mathrm{T}}\left(d^{\mathrm{T}}\cos\gamma^{\mathrm{T}} + \sin\gamma^{\mathrm{T}}\right)}{\cos\gamma^{\mathrm{T}} - d^{\mathrm{T}}\sin\gamma^{\mathrm{T}}}; \\[3mm] \dot{\gamma}^{T} = \alpha^{T}\beta^{T} + vB_{x}^{T}\dfrac{\operatorname{tg}\gamma^{T}}{l^{T}}; \\[3mm] \dot{\varphi}_{11}^{T} = \dfrac{vC_{11_{xy}}}{Z_{C_{11}}^{T}}; \ \dot{\varphi}_{12}^{T} = \dfrac{vC_{12_{xy}}}{Z_{C_{21}}^{T}}; \\[3mm] \dot{\varphi}_{21}^{T} = \dfrac{vC_{21_{xy}}}{Z_{C_{21}}^{T}}; \ \dot{\varphi}_{22}^{T} = \dfrac{vC_{22_{xy}}}{Z_{C_{22}}^{T}}; \\[3mm] \dot{\gamma}^{C} = \dfrac{vyA^{C}}{l_{1}^{C} - hf_{x}^{C}} + \alpha^{C}\beta^{C}; \\[3mm] \dot{\varphi}_{1}^{C} = \dfrac{vC_{1x}^{C}}{Z_{C_{1}}^{C}}; \ \dot{\varphi}_{2}^{C} = \dfrac{vC_{2x}^{C}}{Z_{C_{2}}^{c}}; \\[3mm] \dot{\varphi}_{1}^{C} = \dfrac{vC_{3x}^{C}}{Z_{C_{3}}^{C}}; \ \dot{\varphi}_{4}^{C} = \dfrac{vC_{4x}^{C}}{Z_{C_{4}}^{C}}; \\[3mm] \dot{\gamma}^{Б} = \dfrac{vyA^{Б}}{l_{1}^{b} - hf_{x}^{Б}} + \alpha^{Б}\beta^{Б}; \\[3mm] \dot{\varphi}_{1}^{Б} = \dfrac{vC_{1x}^{b}}{Z_{C_{1}}^{Б}}; \ \dot{\varphi}_{2}^{Б} = \dfrac{vC_{2x}^{b}}{Z_{C_{1}}^{Б}}. \end{cases} \qquad (6)$$

Consider the results of theoretical research of mathematical models of the dynamics of the combined tractor unit for example unit John Deere 8345R + John Deere 1840 + John Deere 1910 (tractor-seeder-hopper) and comparable to the study of the dynamics of the MTA while block in the sequence tractor-hopper drill. Simulation results and comparisons are shown in Fig. 3, Fig. 4.
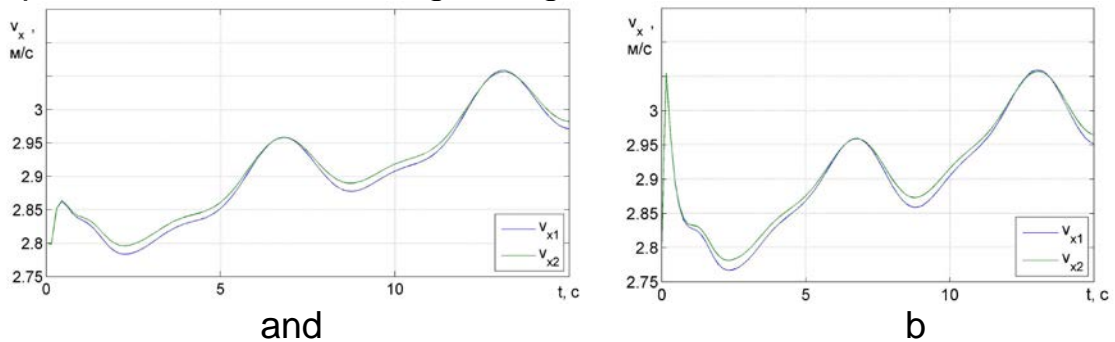

and b

Fig. 3. Gradual speed hopper center of gravity (v_{x1}) And engines (v_{x2}) At block-tank tractor-seeder (a) and tractor-seeder-hopper (B).

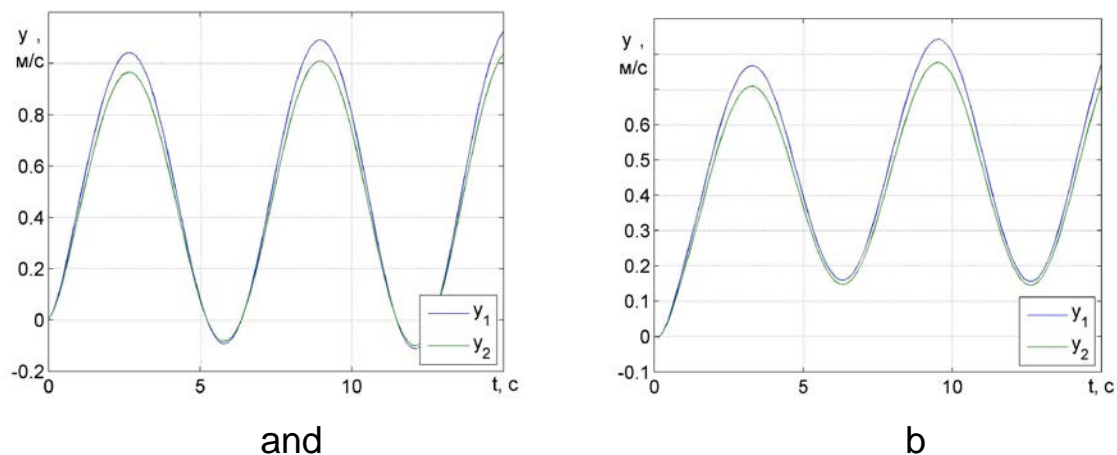|	
and	b

Fig. 4. Rejection of the centers of mass center of gravity hopper (y_1) And engines (y_2) At block-tank tractor-seeder (a) and tractor-seeder-hopper (B).

Gradual speed elements of the unit (Fig. 3) for the circuit block tractor-seeder-hopper lower than 5% for the scheme tractor-seeder hopper. Accordingly, fluctuation deviations from the elements MTA straight path below (Fig. 4). This reduces the energy consumption for unit movement and execution of technological operations and reduced fuel consumption by 3-5%.

Conclusions

1. The proposed methodology study the dynamics of multiple units allows a short time to compare the dynamic performance of their functions and block diagrams and draw conclusions about efficiency.

2. block Drill John Deere 8345R + John Deere 1840 John Deere 1910 + scheme tractor-seeder-hopper in some cases can reduce the instantaneous velocity elements of the unit by 5% and reduce fluctuation deviations from the elements MTA straight trajectory.

3. Reducing the dynamic performance MTA reduces the energy consumption for unit movement and execution of technological operations and reduced fuel consumption by 3-5%.

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In the work opredelena Effective structure posevnoho tractor unit at the expense of the study matematycheskoy ego dynamics model. Pryvedenпыe calculation results Speed posevnoho elements and deflection unit as pryamolyneynoy trajectory motion.

Matematycheskaya model dynamics, tractor, tank, seyalka.

The paper identified an effective structure of sowing tractor unit due to the mathematical model study its dynamics. The results of calculation speeds elements sowing aggregate and deviations from the straight trajectory.

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