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MATHEMATICAL MODEL OF A HARVEST COMBINE FOR THE RECEPTION OF FUEL CHIPS FROM FAST-GROWING PLANTS

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Summary. The article presents a mathematical model for research of dynamic loadings in a branched-out drive of active working bodies of a mowing down and crushing path of a harvest combine for the reception of fuel chips from fast-growing plants.

Key words: a harvest combine, mathematical model, dynamic loadings in a drive, mowing down and crushing mechanisms.

INTRODUCTION

With own fuel and energy resources the technology of use of the developed peat deposits for cultivation of fast-growing plants (shrubbery, a poplar, a grey alder, a willow, etc.) on recovery peat areas – power plantations, their subsequent crushing in a fuel biomass-chips and burning, for the purpose of reception of thermal energy, steam, warm water, the electric power for small, economy can provide an essential contribution to the decision of a problem of power supply of small economy.

Such technology can be economically effective and provides reduction of purchases of other energy carriers. Examples of its realisation are available in Poland, Finland and other countries [1, 2]. Thus cleaning of green vegetation and its crushing, for example, can be executed by a combine for corn of firm Claas with a special harvester and a grinder. The combine works with a semi-trailer-store which has the big height of self-unloading platforms.

In Belarus and Poland the machines are available, however not willingly used and, frequently, there are strong grows of shrubs on the mineral and peat areas, suitable for realisation of the mentioned technology after recovery. Machine maintenance is simply realised satisfactorily on the basis of the machine let out in our countries: universal wheel tractor chassis or self-propelled combines, modules-adapters for tidying of corn harvesters, fell cars and generator of heat and gas.

Creation of a specialised harvest combine for the mentioned technology by use of ready modules-adapters is a rational way of fast working-out of the new vehicle. However, it is necessary to provide safety in operation of such machines at the expense of maintenance of comprehensible dynamic loadings in the branched-out drive of active working bodies: the drum-type cutting off device and the crushing mechanism. In connection with the above-stated a high scientific and practical interest is represented by a technique of definition of the maximum dynamic loadings of transmission branches of the harvest combine intended for reception of the crushed biomass from fast-growing plants for a design stage. Development of modern methods of modelling of technical systems allows to adequately carry out such research by means of mathematical modelling [3, 4, 6-9].

DYNAMIC SYSTEM OF THE HARVEST COMBINE

The scheme of a harvest combine for the reception of crushed biomass or fuel chips from fast-growing vegetation, dynamic models of a running system, a harvester and crushing mechanism path, resulted from one engine, are shown in Figures 1-3.

The dynamic system of a combine with the drum-type cutting bodies, intended for mowing down and crushing of wood vegetation, includes a drive of the left and right drums of a harvester, a drive fell of the drum; a drive of the top and bottom submitting rollers; a drive of the thrower. The drives test considers dynamic loadings at interaction with the initial vegetative material. In a design choice of parameters of drives of these cars it is necessary to consider their dynamic load level.

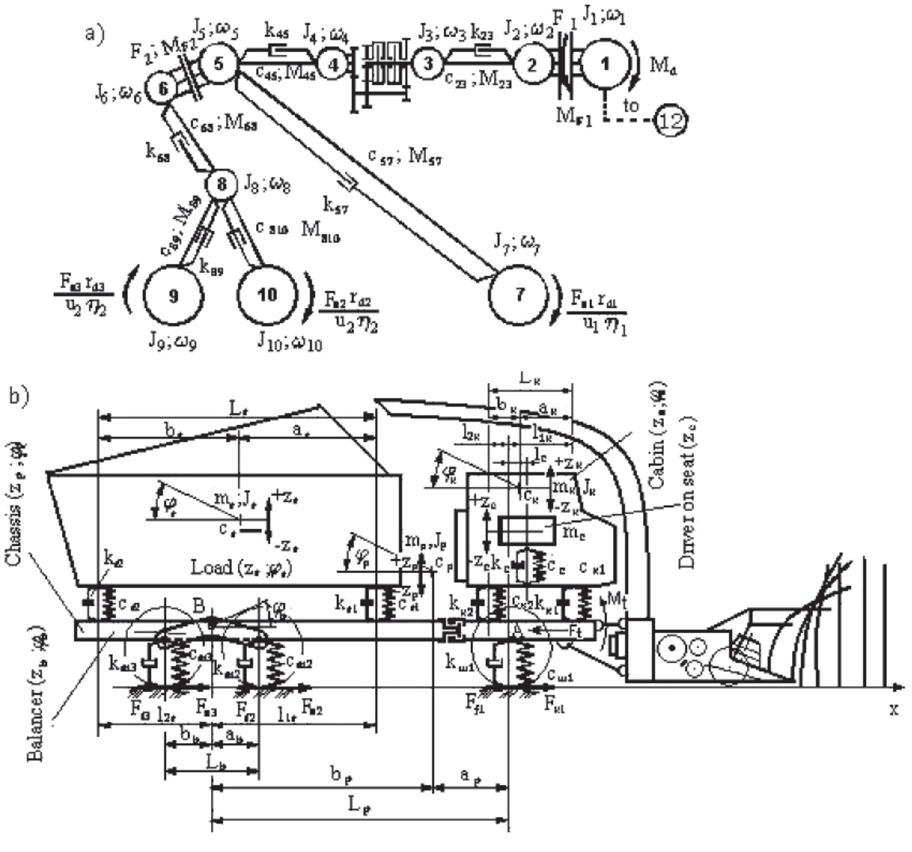

Fig. 1. The scheme and settlement dynamic model of a harvest combine

At drawing up of dynamic system and the mathematical description of its functioning, methods of analytical mechanics accept the following assumptions: the dynamic system of transmission can be presented in the form of discrete with the concentrated weights connected by non-inertial elastic communications [3]; there is considered longitudinal and cross-section rigidity of a processed pack of wood vegetation; the thickness of a pack of a processed wood material on length changes as monotonous stochastic function.

Working process of a combine is non-stationary and consists of unsteady processes of cutting of plants at lower parts drums of a harvester, advancement of non-fell vegetative weight in reception port fell of the drum with participation of submitting workers of bodies, crushing knives of the cutting drum, loadings of the received biomass-chips by the thrower in replaceable or self-unloading platform-store placed in the backof semi-frame of the combine.

Settlement of dynamic systems of a combine is developed at assumptions, characteristic for the decision of similar problems [4].

In Fig. 1 the settlement scheme of a combine which includes dynamic system of transmission (Fig. 1) and oscillatory system of the car is presented at movement on roughnesses of a basic surface (Fig. 1).

In dynamic system of transmission the following designations are accepted: I_1, ω_1 – the moment of inertia of rotating details of the engine and angular speed of rotation of its cranked shaft; I_2, ω_2 – the moment of inertia of conducted details of coupling and its angular speed; I_3, I_4, ω_3, ω_4 – the moments of inertia and angular speeds and, accordingly, details on the leader and a permission shaft of a transmission and their angular speeds; I_5, ω_5 – the moment of inertia of details of a distributing box and its angular speed; I_6, ω_6 – the moment of inertia of a conducted part of the connect device managements of back leading bridges and its angular speed; I_7, ω_7 – the moment of inertia of forward driving wheels and their angular speed; I_8, ω_8 – the moment of inertia of details of the leading back bridge, including a final drive cogwheel from which the twisting moment is distributed on the first and second back wheels, and its angular speed; I_9, I_{10}, ω_9, ω_{10} – the moments of inertia of back wheels and their angular speeds; c_{ij}, k_{ij} – rigidity and put out energy of oscillation in *ij* sites of transmission (i=2,4,5,6,8; j=3,5,7,8,9,10); M_{ij} – the elastic (dynamic) moments in *ij* sites of transmission; F_1, F_2 – accordingly, coupling and connect device inclusions-deenergizings of the back bridge; M_{dv} – the twisting moment of the engine; $F_{ki}r_i\,/\,(U_i\eta_i)$ – the twisting moments of driving wheels (i=7,9,10): F_{ki} – the tangent force of draught developed by wheels *of i-th* bridge; r_{di} – dynamic radius of wheels *of i-th* bridge; $U_i=U_{кп}U_{рк}U_M$ – transfer number from the engine to wheels *of i-th* bridge, here $U_{кп,}$ $U_{рк,}$ U_M – transmission transfer numbers, accordingly, the distributing box, the leading bridge; η_i – drive efficiency to wheels *of i-th* bridge: φ – factor of coupling of wheels with a basic surface; G_i – the vertical loading falling *i*-th to the bridge; k – the factor depending on properties of a basic surface; δ_i – slipping of wheels *of i-th* bridge: ϑ_{Ti} – theoretical speed of the centres of wheels *of i-th* bridge; $\vartheta = x$ – the valid speed of the car; ω_i – angular speed of wheels *of i-th* bridge.

Designated in drawing 1б parametres of oscillatory system of a combine include: m_p, I_p; m_k, I_k; m_r, I_r; m_b, I_b – weights and the inertia moments accordingly frames of the car with the equipment (the engine, transmission, a platform etc.), cabins, cargo, the balance weight; m_c – weight of a seat with the driver; c_p, $c_к$, c_r – the centres of weights accordingly frames, cabins, cargo; a_p, $в_p$; $a_к$, $в_к$; a_r, $в_r$; a_b, $в_b$ – distances from a forward and back support to the centre of weights, accordingly, frames, cabins, cargo, the balance weight; c_{mi}, k_{mi}; c_{ki}, k_{ki}; c_{ri}, k_{ri} – rigidity and put out tyres, a suspension bracket of a cabin, a cargo suspension bracket; c_c, κ_c – rigidity and put out suspension brackets of a seat of the driver.

All elements entering into the dynamic system of transmission of the car are led to a cranked shaft of the engine.

The system of the differential equations describing work of transmission and running system of the tractor chassis, on the basis of which the harvest combine is generated, is stated in work [4] and owing to great volume here is not resulted.

In connection with an influence on the skeleton of a combine of resistance of giving of a harvester and bending moment in a longitudinal-vertical plane from connection with the technological module these power factors should be considered in the mentioned system of equations. Values of these power factors and a line of action of force of resistance of giving are defined from consideration of the equations of balance of the technological module taking into account the moving resistance of basic wheels, resistance (along a direction of movement of a combine) to cutting and oppression top forking by a bar of plants on width of capture of a harvester. The maximum effort of cutting of vegetation can be calculated on an empirical dependence taking into account specific resistance to cutting, density of planting of concrete wood vegetation on a power plantation and width of capture of a harvester [5]:

$$F_r = \frac{B}{q} \cdot \left(k_1 + k_2 \cdot d_s\right) \cdot d_s, \text{ H},$$

where: B – width of capture of a harvester, m; q – width of row-spacings of planting, m; in k_1 H/m, in k_2 H/m^2 – empirical factors; d_5 – average diameter of a cut off plant, m. Then average values of moments M_r and M_l resistance to cutting on the knifes of drums of a harvester located on radius, R_b will be defined from the expression:

$$M_{r,} M_l = \frac{B}{q} \cdot \left(k_1 + k_2 \cdot d_s\right) \cdot d_s \cdot R_b.$$

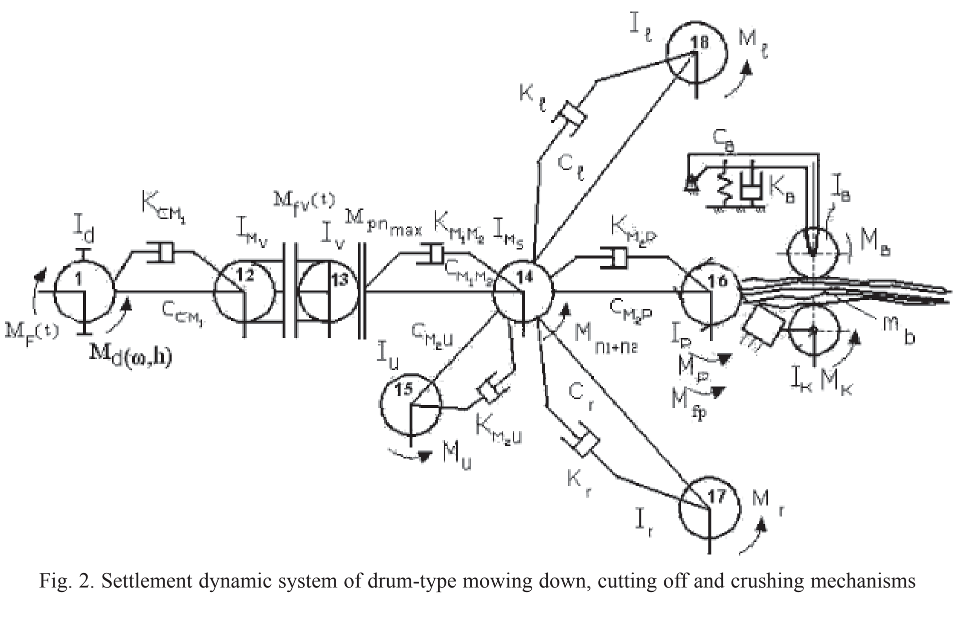

Fig. 2. Settlement dynamic system of drum-type mowing down, cutting off and crushing mechanisms

On the scheme of dynamic system of a drive of the technological module it is designated (Fig. 2):

$M_{\hat{a}}(\omega,h)$ – The engine moment, depending on angular speed and position of the lock teeth of the fuel pump; $M_F(t)$ – the moment of connect device couplings; I_d – the moment of inertia of the engine; $I_{\grave{i}\,v}, I_v, I_{\grave{i}\,s}, I_u, I_{\eth}, I_{\hat{e}}, I_r, I_{\hat{a}}, I_l$ – the moments of inertia led to a shaft of the engine, accordingly: details of a shaft of a drive of an independent shaft of selection of capacity (SSC) and a leading part of connect device inclusions independent SSC; conducted parts connection SSC and a leading pulley belting transfers; a conducted pulley belting transfers; a rotor of the thrower; a cutting rotor; bottom reception shaft; top clamping shaft; rotating knifing parts of the right and left drums of a harvester; $M_{fv}(t)$ – the friction moment in connection inclusions SSC; $M_{\eth\ddot{\imath}\max}$ – the maximum moment of a friction in contact belts with a pulley; M_{n1+n2} – the total moment in drives of the first and second hydropumps; $M_{\eth}$ – the moment of resistance to the cutting, enclosed to a cutting rotor; $M_{\hat{a}}$, $M_{\hat{e}}$ – the twisting moment developed accordingly, top and bottom shaft; $m_{\acute{a}}$ – weight of a crushed pack of wood vegetation; c_{ij} – led to a shaft of the engine of rigidity of parts of a drive between the corresponding concentrated weights of dynamic system; k_{ij} – led to a shaft of the engine factors of non- elastic resistance to relative turn of weights of dynamic system at rotating fluctuations; $k_{\hat{a}}$, $c_{\hat{a}}$ – factor of non- elastic resistance and rigidity of a suspension bracket top clamping submitting shaft.

The scheme of dynamic interaction with a crushed pack of wood vegetation cutting and submitting workers of bodies is shown in Fig. 3.

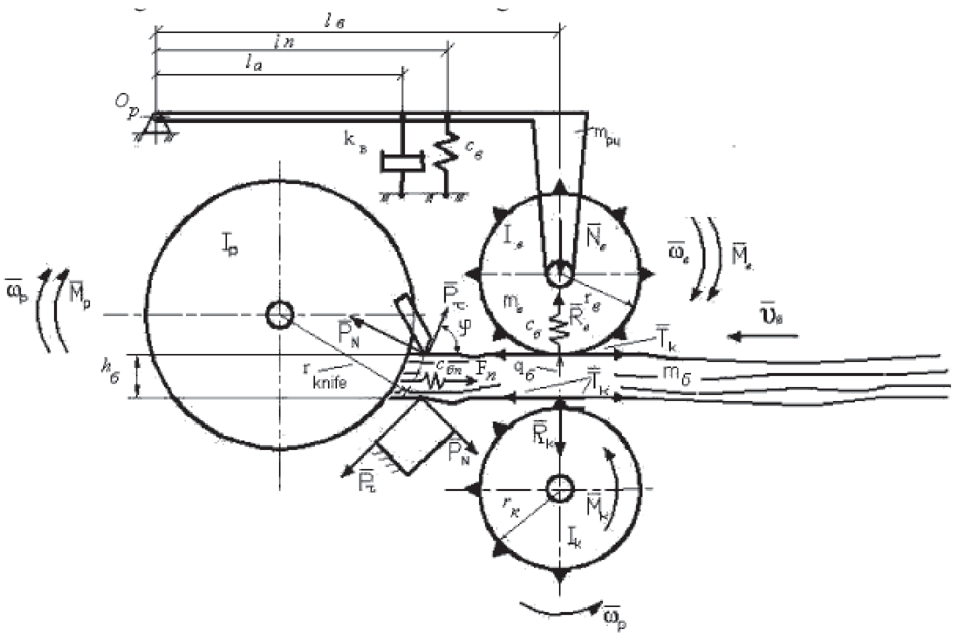

Fig. 3. The scheme of interaction of working bodies with a pack of wood vegetation

The sense of the additional designations resulted on the scheme, basically, is clear in the drawing. In Fig. 3 longitudinal and cross-section rigidity of the last, kinematic co-ordinate of its variable thickness, distance from an axis of rotation of the lever with clamping shaft to its axis of rotation and to places of fastening of the shock-absorber and a clamping spring of a stretching are shown also by horizontal reaction from a drum on a material pack.

THE MATHEMATICAL DESCRIPTION OF DYNAMIC SYSTEM OF THE TECHNOLOGICAL MODULE

For simplification of record of mathematical model indexes at the moments of the inertia, the twisting moments and angular speeds we will write down taking into account corresponding numbers of the concentrated weights of dynamic system.

The differential equations of movement of weights of settlement dynamic system of a drive of active working bodies (Fig. 2) look like:

$$I_1 \cdot \dot{\omega}_1 = M_d(\omega,h) - M_{1,12} - M_F(t) - k_{CM1} \cdot (\omega_1 - \omega_{12}),$$

– at inclusion of connect device couplings, and after kinematics short circuit connection device couplings: [$\omega_1 = \omega_2 = \omega_{1,2}$ 1]:

$$(I_1 + I_2) \cdot \dot{\omega}_{1,2} = M_d(\omega,h) - M_{1,12} - M_F(t) - k_{CM1} \cdot (\omega_1 - \omega_{12}),$$
$$\dot{M}_{1,12} = c_{CM1}(\omega_1 - \omega_{12}).$$

The engine moment undertakes [1] from the description of its high-speed characteristic.

At inclusion connection device its moment is defined from expressions:

$$M_f(t) = k_f \cdot t;\; k_f = \frac{M_{f\max}}{T_{on}};\; \text{or,}\, M_f(t) = M_{f\max}\left(1 - e^{-k_f^* t}\right),$$

k_f, k_f^* – a factors of approximation of the law of operation connection device; $M_{f\,max}$ – the maximum moment of a friction in connection device after power short circuit.

$$I_{12} \cdot \dot{\omega}_{12} = M_{1,12} - M_f(t) + k_{CM1} \cdot (\omega_1 - \omega_{1,12}),$$
$$I_{13} \cdot \dot{\omega}_{13} = M_f(t) - M_{13,14} + k_{M1M2} \cdot (\omega_{13} - \omega_{14}),$$

and after kinematics short circuit connection device and $\omega_{12} = \omega_{13}$

$$(I_{12} + I_{13}) \cdot \dot{\omega}_{12} = M_{1,12} - M_{13,14} - k_{M1,M2} \cdot (\omega_{13} - \omega_{14});$$
$$\text{or}\quad (I_{12} + I_{13}) \cdot \dot{\omega}_{13} = M_{1,12} - M_{13,14} - k_{M1,M2} \cdot (\omega_{13} - \omega_{14}).$$

$$I_{14} \cdot \dot{\omega}_{14} = M_{13,14} + k_{M1M2} \cdot (\omega_{13} - \omega_{14}) - \\ - \begin{bmatrix} M_{n1} + M_{n2} + M_{14,15} + M_{14,17} + M_{14,18} + k_{M2P} \cdot (\omega_{14} - \omega_{16}) \\ + k_{M2u}(\omega_{14} - \omega_{15}) + k_r(\omega_{14} - \omega_{17}) + k_l(\omega_{14} - \omega_{18}) \end{bmatrix};$$

$$I_{15} \cdot \dot{\omega}_{15} = M_{14,15} - M_u + k_{M2u} \cdot (\omega_{14} - \omega_{15});$$
$$I_{16} \cdot \dot{\omega}_{16} = M_{14,16} + k_{M2P} \cdot (\omega_{14} - \omega_{16}) - M_\partial - M_{f\partial};$$
$$I_{17} \cdot \dot{\omega}_{17} = M_{14,17} - M_r + k_r \cdot (\omega_{14} - \omega_{17})$$
$$I_{18} \cdot \dot{\omega}_{18} = M_{14,18} - M_l + k_l \cdot (\omega_{14} - \omega_{18})$$
$$\dot{M}_{13,14} = c_{M1M2}(\omega_{13} - \omega_{14}).$$

In a case slipping belts concerning a leading pulley:

$$\dot{M}_{13,14} = c_{M1M2}\left(\omega_{13} - \omega_{14}^d \cdot \frac{1}{1 - \delta_{\partial\ddot{\imath}}}\right);\; M_{13,14} = M_{\partial\ddot{\imath}\max} \cdot \left(1 - e^{k_{\partial\ddot{\imath}}\delta_{\partial\ddot{\imath}}}\right),$$

whence:

$$\delta_{\eth \ddot{\imath}} = \frac{\omega_{13} - \omega_{14}^{d}}{\omega_{13}} = -\frac{1}{k_{\eth \ddot{\imath}}} \cdot \ln\left(\frac{M_{\eth \ddot{\imath}\max} - M_{13,14}}{M_{\eth \ddot{\imath}\max}}\right),$$

where: $\delta_{\eth \ddot{\imath}}$ – slipping belts of a drive of active working bodies, then the valid angular speed of rotation of 14-th mass of dynamic system will be defined from the expression:

$$\omega_{14}^{d} = \omega_{14}\left(1-\delta_{\eth \ddot{\imath}}\right),\ \omega_{14} = \frac{\omega_{14}^{d}}{1-\delta_{\eth \ddot{\imath}}};$$

$$\dot{M}_{14,15} = c_{M2u}\left(\omega_{14}-\omega_{15}\right); \dot{M}_{14,16} = c_{M2P}\left(\omega_{14}-\omega_{16}\right);$$

$$\dot{M}_{14,17} = c_{r}\left(\omega_{14}-\omega_{17}\right); \dot{M}_{14,18} = c_{l}\left(\omega_{14}-\omega_{18}\right)$$

$$m_b \cdot \dot{v}_b = P_\tau \cdot \cos\varphi - P_N \cdot \sin\varphi + \frac{M_{\hat{a}}}{r_{\hat{a}}} + \frac{M_{\hat{e}}}{r_{\hat{e}}} - F_N;$$

$$\dot{F}_N = c_{b\ddot{\imath}}\left(\dot{l}_{str} - v_b\right),$$

where: m_b – the weight of a submitted material, is a decreasing variable. Weight reduction in direct ratio to frequency of rotation, number of knives of a cutting drum, the area of cross-section of a material and its density, at an assumption about a density constancy on length of a crushed material; P_τ, P_N – tangential and normal making efforts of cutting; φ – a corner of a meeting of a knife with the material.

$$I_{\hat{a}} \cdot \dot{\omega}_{\hat{a}} = M_{\hat{a}} - R_{\hat{a}} \cdot \varphi_{\hat{a}\max} \cdot \left(1 - e^{k_{\hat{a}}\delta_{\hat{a}}}\right);\ I_{\hat{e}} \cdot \dot{\omega}_{\hat{e}} = M_{\hat{e}} - R_{\hat{e}} \cdot \varphi_{\hat{e}\max} \cdot \left(1 - e^{k_{\hat{e}}\delta_{\hat{e}}}\right),$$

where: $\varphi_{\hat{a}\max}$ $\varphi_{\hat{e}\max}$ – factors of coupling of ledges clamping and bottom shaft with the material; $\hat{e}_{\hat{e}}, \delta_{\hat{e}}$ – factor of approximation of a curve and slipping bottom shaft concerning the material; $\hat{e}_{\hat{e}}, \delta_{\hat{e}}$ – factor of approximation of a curve and slipping clamping shaft concerning a material.

Sizes $R_{\hat{a}} = R_{\hat{e}}$ are defined by rigidity of a pack of wood vegetation between submitting working bodies.

The equation of movement of the lever with clamping shaft represents the equation of balance of the moments concerning a point O_p:

$$c_{\acute{a}} \cdot \left(h_{\acute{a}} - h_{\min}\right) + k_{\acute{a}} \cdot \omega_{\eth} \cdot \operatorname{sign}\omega_{\eth} + m_{\eth\div} \cdot \frac{d^2 q_{\acute{a}}}{dt^2} +$$

$$+ I_{\eth\div} \cdot \frac{1}{l_{\hat{a}}} \cdot \frac{d^2 q_{\acute{a}}}{dt^2} - c_{\acute{a}} \cdot \frac{l_n}{l_{\hat{a}}} \cdot \left(h_{\acute{a}} - h_{\min}\right) - k_{\acute{a}} \cdot \frac{l_A}{l_{\hat{a}}} \cdot \frac{dq_{\acute{a}}}{dt} = 0;$$

$$R_{\hat{a}} = R_{\hat{e}} = c_{\acute{a}}\left(h_{\acute{a}} - h_{\min}\right) + k_{\acute{a}} \cdot \omega_{\eth} \cdot \operatorname{sign}\omega_{\eth},$$

where: $q_{\acute{a}}$ – ordinate of the thickness of the submitted material.

The moments and angular speeds of hydro-cars used for a drive-submitting crushing mechanism are defined on following known dependences [10, 11]:

$M_{n_1} = \dfrac{\Delta p_{n_1} \cdot q_{Tn_1} \cdot \eta_{n_1}}{2\pi}$ – the moment necessary on the drive of the first pump;

$q_{Tn_1} = \dfrac{\pi d_{n_1}^2}{4} \cdot Z_{n_1} \cdot D_{n_1} \cdot \operatorname{tg}\beta_{n_1}$ – specific giving of the first pump;

$\omega_{n_1} = \omega_{n_2} = \omega_{14} = \dfrac{\eta_{0n_1} Q_{n_1}}{q_{Tn_1}} = \dfrac{\eta_{0n_2} Q_{n_2}}{q_{Tn_2}}$ – angular speeds of pumps;

$M_{n_2} = \dfrac{\Delta p_{n_2} \cdot q_{Tn_2} \cdot \eta_{n_2}}{2\pi}$ – the moment necessary on the drive of the second pump;

$q_{Tn_2} = \dfrac{\pi d_{n_2}^2}{4} \cdot Z_{n_2} \cdot D_{n_2} \cdot \operatorname{tg} \beta_{n_2}$ – specific giving of the second pump;

$\delta_{\hat{a}} = \dfrac{\omega_{\hat{a}} \cdot r_{\hat{a}} - v_{\acute{a}}}{\omega_{\hat{a}} \cdot r_{\hat{a}}}$ – dimensionless size slipping shaft concerning the material;

$$M_{\hat{a}} = M_{M_{\hat{a}}} = \frac{\Delta p_{M_{\hat{a}}} \cdot q_{TM_{\hat{a}}} \cdot \eta_{M_{\hat{a}}}}{2\pi};\ q_{TM_{\hat{a}}} = \frac{\pi d_{M_{\hat{a}}}^2}{4} \cdot Z_{M_{\hat{a}}} \cdot D_{M_{\hat{a}}} \cdot \operatorname{tg} \beta_{M_{\hat{a}}};$$

$$\omega_{\hat{a}} = \omega_{M_{\hat{a}}} = \frac{\eta_{0M_{\hat{a}}} Q_{M_{\hat{a}}}}{q_{TM_{\hat{a}}}};\ \delta_{\hat{e}} = \frac{\omega_{\hat{e}} \cdot r_{\hat{e}} - v_b}{\omega_{\hat{e}} \cdot r_{\hat{e}}};\ M_{\hat{e}} = M_{M_{\hat{e}}} = \frac{\Delta p_{M_{\hat{e}}} \cdot q_{TM_{\hat{e}}} \cdot \eta_{M_{\hat{e}}}}{2\pi};$$

$$q_{TM_{\hat{e}}} = \frac{\pi d_{M_{\hat{e}}}^2}{4} \cdot Z_{M_{\hat{e}}} \cdot D_{M_{\hat{e}}} \cdot \operatorname{tg} \beta_{M_{\hat{e}}};$$

Instant second volume productivity of the crushing mechanism in material crushing:

$q_{rub} = S_{window} \cdot h_b \cdot v_b$; $M_{fr} = F_N \cdot f_{br}$ – the moment of friction of an end face of the material between knives of the drum surface; $\overline{P}_\tau + \overline{P}_N = \overline{P}_{rez}$; $p_{ud} = p(\alpha) \cdot a_\rho \cdot a_w \cdot a_s \cdot a_t$ – specific, on unit of width of the material, force of cutting; $a_\rho \cdot a_w \cdot a_s \cdot a_t$ – product of correction factors, accordingly, on degree edge knives, on humidity of wood vegetation, on the case of frozen wood use, on breed of wood vegetation.

$P_{rez} = p_{ud} \cdot h_b \cdot s$; $P_\tau = P_{rez} \cdot \cos\varepsilon$; $P_N = P_{rez} \cdot \sin\varepsilon$; $\dot{l}_{str} = n_{nog} \cdot l_{chep} \cdot \omega_{16}$ – speed of shortening of a pack of wood vegetation in a giving direction (Fig. 3 and 4);

$$l_{chep} = \frac{h_{chep} \cdot R}{\sqrt{R^2 - (A - h_b)^2}},$$

where: l_{chep}, h_{chep} – length and thickness received by chips; n_{nog} – number of knives; other designations are understood from Fig. 4.

Volume hour productivity of the crushing mechanism considers the running cycle's structure and is defined from the expression:

$$Q_{M_b} = \frac{k_{razr}}{T_u} \int_0^{T_u} n_{nog} \cdot l_{chep} \cdot \omega_{16} \cdot h_b \cdot s \cdot dt;$$

Some necessary auxiliary sizes are defined from the expressions (Fig. 4): $OD = A - h_b$;

$$\sin\varepsilon = \frac{OD}{R} = \frac{A - (h_b - \omega_{16} \cdot R \cdot t_{rez})}{R},$$

$$\text{at } \arcsin\frac{A}{R} > \varepsilon > \arcsin\frac{A - h_b}{R};\ h_b^* = h_b - \omega_b \cdot R \cdot t_{rez};$$

$$\cos\varepsilon = \frac{\sqrt{R^2 - (A - h_b)^2}}{R};\quad l_{chep} \approx h_{chep} \cdot \frac{1}{\cos\varepsilon} = \frac{h_{chep} \cdot R}{\sqrt{R^2 - (A - h_{chep}^*)^2}};$$

$$\alpha + \beta + \varphi = \pi;\qquad p_{ud} = p(\varepsilon) \cdot a_\rho \cdot a_w \cdot a_s \cdot a_t;$$

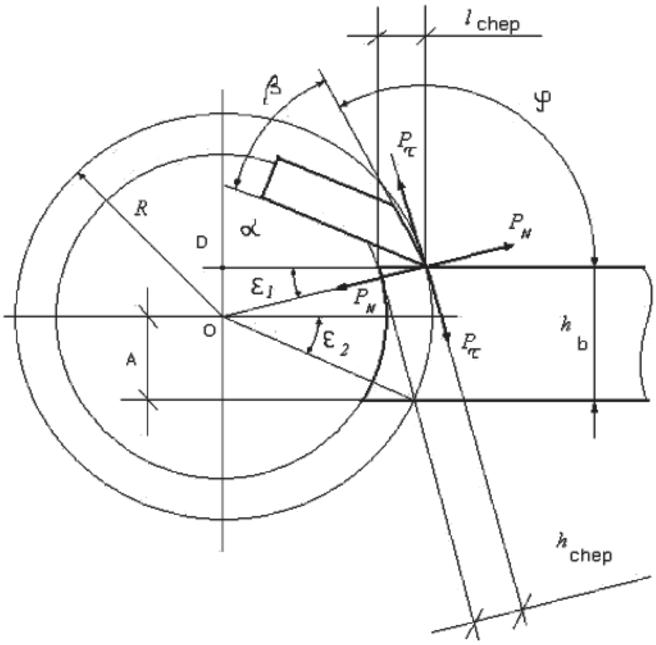

Fig. 4. The scheme of the cutting parameters definition

$$p_{rez} = p_{ud} \cdot h_b \cdot s\,;$$

For rotating the thrower with radial blades, as a first approximation:

$$M_u = m_{sch} \cdot \omega_{15}^2 \cdot \frac{R_l + r_b}{2} \cdot f_{tr} \cdot R_l,$$

where: m_{sch}– weight chips, co-operating with blades of a rotor of the thrower; r_b – radius of a shaft of a rotor of the thrower; R_l – radius on the ends of blades of the thrower; f_{tr} – factor of a friction of the material chips with the blade of the thrower.

Solving all the developed systems of equations we will receive the full information on combine movement in the set conditions of operation, about rotating weights fluctuations and the dynamic moments in drives of all the active working bodies, and also about parameters of casual fluctuations of subsystems of the unit, at movement on roughnesses of a basic surface and dynamic power factors, in places of fastening of wheels, balance weights, a cabin and the cargo, cars operating on semi-frames, necessary for valid calculation of drives of active working bodies and for an estimation of smoothness of a combine course.

CONCLUSIONS

The developed mathematical model of a harvest combine for the reception of the crushed biomass or fuel chips from fast-growing vegetation allows to make the multiple pre-design parametrical analysis of dynamics of its working process, for the purpose of the subsequent choice of rational constructive and regime parametres.

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