Computing of Design Equations for Dynamics of Mini-Tractor

(Mathematical Model)

In order to better present the energy dissipation on partial skidding of drives (wheels) as well as functional purpose of the elastic muffs, for the purpose of increasing the torsion pliability, it is reasonable to reflect their influence on rolling radius in differential equation system, that describe the manner of design dynamic system "body-transmission (see Pic.2,8) in plowing regime over deformable and conditioanlly uniform ground:

$$\begin{cases} 1. I_1\ddot{\varphi}_1 = M - C_{12}(\varphi_1 - \varphi_2) - K_{12}(\dot{\varphi}_1 - \dot{\varphi}_2); \\ 2. I_2\ddot{\varphi}_2 = C_{12}(\varphi_1 - \varphi_2) + K_{12}(\dot{\varphi}_1 - \dot{\varphi}_2) - r_K P_K (i\eta)^{-1}; \\ 3. I_a\ddot{\varphi}_a = (P_K - P_f - C_X X - K_X \dot{X}) - P_P(h_1 - h_2) - [c_z(q - z) + K_z(\dot{q} - \dot{z})](b - a) - \\ -(c_z\varphi_a + K_z\dot{\varphi}_a)(a^2 + b^2); \\ 4. m\ddot{Z} = (c_z\varphi_a + K_z\dot{\varphi}_a)(b - a) - 3[c_z(q - z) + K_z(\dot{q} - \dot{z})]; \\ 5. m\ddot{X} = P_K - P_f - C_X X - K_X \dot{X}. \end{cases} \quad (2.20)$$

where,

$$I_2 = mV^2\varphi_2^{-2} + \Sigma I_j \varphi_j^2 \quad j = \overline{1,n};$$

$$I_a = mV^2\varphi_a^{-2};$$

$$P_K = \frac{C_{12}[(\varphi_1 - \varphi_2)r_K + X] + K_{12}[(\dot{\varphi}_1 - \dot{\varphi}_2)r_K + \dot{X}]}{|h_2 + r_K|};$$

$$P_f = mg(f\cos\alpha + \sin\alpha);$$

$$P_P = h_P b_P (K_P + \varepsilon V^2);$$

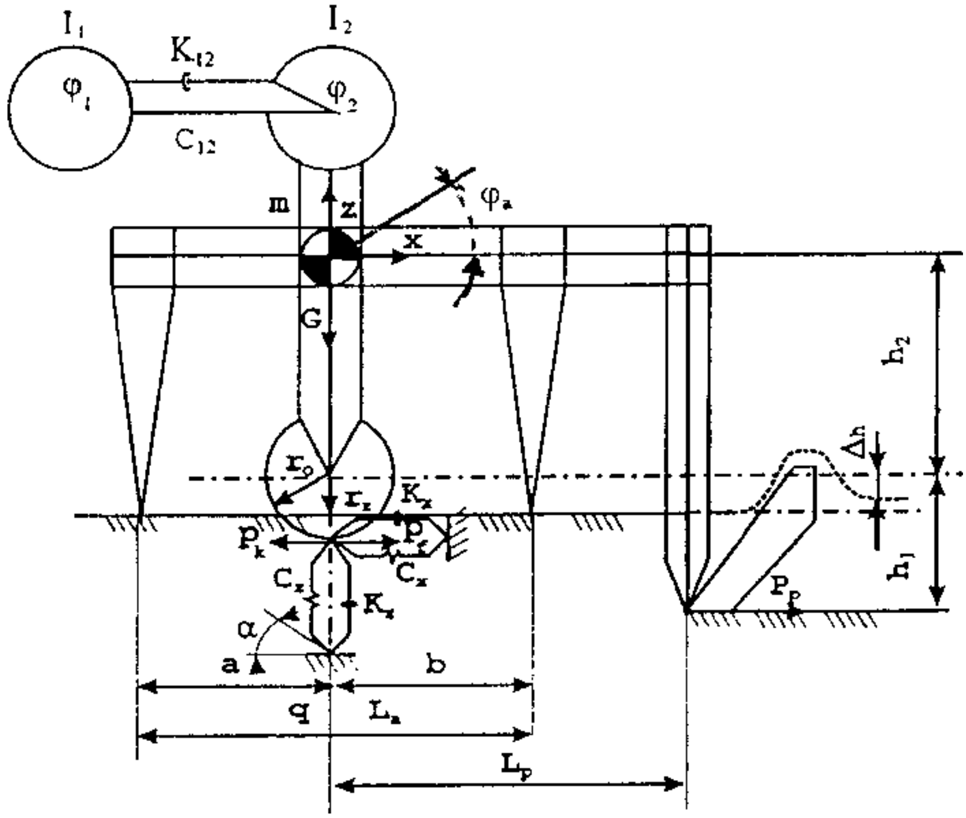
$$V = \dot{\varphi}_2 r_K i^{-1} - \dot{X} sign\dot{q};$$

$$r_K = 0{,}5\left[r_Z + \left(r_Z^2 - 4M_f \lambda C_{12} C_K^{-1} \psi \delta^{-1}\right)^{0,5}\right];$$

$$r_Z = r_0 - mgC_X^{-1} - q + z;$$

$$h_K = h_1 + r_K; \quad h_P = h_2 + r_K;$$

As folllows from above given expression, reducing the transmission rigidity (by using the elastic muffs in wheel drive) under the changing loads, leads to an increase in rolling radius. Consequently, the forward motion velocity and plow resitance force (realization of power) go up, but dynamic load of transmission goes down (at the expense of increase in pliability). Thus and so, the tractor efficiency goes up. Also, there are increasing the static constituents and reducing the dynamic constituents of the transmission load. Simplification of the system is possible with an assumption that tractor's velocity is low and oscillations of body are ignored, but the wheels are considered conditionally as non-elastic ones and their radiuses are the same.



Pic2.8. Design Dynamic System “Body-Transmission”

$$
\begin{cases}
I_1\ddot{\varphi}_1 - K_{12}(\dot{\varphi}_2-\dot{\varphi}_1) - C_{12}(\varphi_2-\varphi_1) = -\dfrac{M\cos\alpha}{|\cos\alpha|}; \\
2.I_2\ddot{\varphi}_2 + K_{12}(\dot{\varphi}_2-\dot{\varphi}_1) + C_{12}(\varphi_2-\varphi_1) - \dfrac{K_{23}K_X}{K_{23}+K_X}\left(\dfrac{\dot{X}}{r_K}-\dot{\varphi}_2\right) - \dfrac{C_{23}C_X}{C_{23}+C_X}\left(\dfrac{X}{r_K}-\varphi_2\right) = 0 \\
3.m\ddot{X} + \dfrac{K_{23}K_X}{(K_{23}+K_X)r}\left(\dfrac{\dot{X}}{r_K}-\dot{\varphi}_2\right) + \dfrac{C_{23}C_X}{C_{23}+C_X}\left(\dfrac{X}{r_K}-\varphi_2\right) = mg(\sin\alpha + f\cos\alpha); \\
4.m\ddot{X}\sin 2\alpha + 2mg\cos\alpha = 2K_Z\dot{h} + 2C_Z h; \\
5.I_2\ddot{\varphi}_2 + K_{12}(\dot{\varphi}_2-\dot{\varphi}_1) + C_{12}(\varphi_2-\varphi_1) = \dfrac{z_K}{\gamma}(z_0 - z_K - h);
\end{cases}
\tag{2.21}
$$

where, $X = \frac{1}{m}\sin 2\alpha\left[2(K_Z\dot{h} + C_Z h) - 2mg\cos\alpha\right]$

$$1.\ \frac{d\varphi_2}{dT} = F_2 = \frac{1}{I_1}\left[K_{12}(\varphi_4-\varphi_2) + C_{12}(\varphi_3-\varphi_1) + M\frac{\cos\alpha}{|\cos\alpha|}\right];$$

$$2.\ \frac{d\varphi_4}{dT} = F_4 = \frac{1}{I_2}\left[\frac{K_{23}K_X}{K_{23}+K_X}\left(\frac{\varphi_6}{\varphi_9}-\varphi_4\right) + \frac{C_{23}C_X}{C_{23}+C_X}\left(\frac{\varphi_5}{\varphi_9}-\varphi_3\right) - K_{12}(\varphi_4-\varphi_2) - C_{12}(\varphi_3-\varphi_1)\right];$$

3. $$\frac{d\varphi_6}{dT} = F_6 = \frac{1}{m}\left[mg(\sin\alpha + f\cos\alpha) - \frac{K_{23}K_X}{(K_{23}+K_X)r}\left(\frac{\varphi_6}{\varphi_9} - \varphi_4\right) - \frac{C_{23}C_X}{(C_{23}+C_X)\varphi_9}\left(\frac{\varphi_5}{\varphi_9} - \varphi_3\right)\right];$$

4. $$\frac{d\varphi_6}{dT} = F_6 = \frac{1}{2m\sin 2\alpha}\left[2(K\varphi_8 + C\varphi_7) - 2mg\cos\alpha\right];$$

5. $$\frac{d\varphi_4}{dT} = F_6 = \frac{1}{I_2}\left[\frac{\varphi_9}{\gamma}(r_0 - \varphi_9 - \varphi_7) - K_{12}(\varphi_4 - \varphi_2) - C_{12}(\varphi_3 - \varphi_1)\right];$$

using the following insertions:

$\varphi_1 \to \varphi_1$; $\dot{\varphi}_1 \to \varphi_2$; $\varphi_2 \to \varphi_3$; $\dot{\varphi}_2 \to \varphi_4$; $X \to \varphi_5$; $\dot{X} \to \varphi_6$;; $h \to \gamma_7$; $\dot{h} \to \gamma_8$.

Chapter Concise Conclusions

1. There is developed mathematical model reflecting the motion dynamics of small wheel tractor, which decribes processes in dynamic system “body-transmission”

2. By using the qualitative methods of research it is possible to define influence of elestic-damping parameters of whhel drive and transmission on rolling resistance and partially on skidding.

3. Reducing of rigidity and improving elastic-damping properties (pliability) of wheel drives by introducing the elastic elements (compact elastic muffs) into between the wheel rims and discs, imrove traction-clutching parameters and operational properties, reduce transmission dynamic load and increase service speed in transportation and plowing regimes.