CONTRIBUTIONS TO THE THEORETICAL STUDY OF THE PRECISION SOWING MACHINES DYNAMICS

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Abstract: *In the paper are elaborated the equivalent dynamical models and main mathematical models of the seeder units of precision sowing machines according to the coupling to the frame mechanism type, oscillatory rod mechanism, oscillatory parallelogram mechanism, balancer mechanism and balancing arm mechanism. The dynamical and mathematical models which are created allow the determination by calculus (computer simulation) of the ground normal reactions upon the compaction wheels as well as of other dynamic and kinematic parameters of the working system for the analyzed sowing sections.*
Key words: *precision seeder, dynamic model, mathematical model, soil reactions, work stability*

INTRODUCTION

The main schemes of the seeder units for precision sowing machines are shown in figure 1, for which there will be made dynamic and mathematical models further on in ideal running conditions, on horizontal terrain at constant speed, in order to establish the parameters on which their stability depends during the working process.

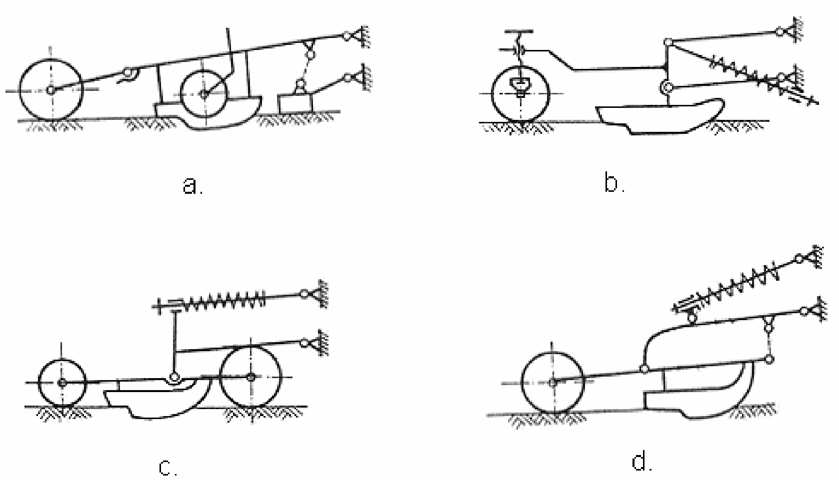

Fig.1. The main schemes of the seeder units for precision sowing machines: a – with oscillatory bar and adjusting working depth wheel; b – with parallelogram mechanism and adjustable settling wheel; c – with balance lever type; d – with oscillatory arm.

MATERIAL AND METHODS

1. Dynamic and mathematical modeling of the mechanism with oscillatory bar and adjusting working depth wheel

From the kinematic and dynamic point of view this type of seeder unit (fig. 2) represents a bar that oscillates around the joint O_1, working depth being adjusted by means of the adjusting wheel for working depth (that rotates around O_4 and radius r). Further on this oscillatory bar there is the joined fork of the settling wheel, which is elastically forced around the joint O_2 with the moment M_l in the direction of increasing normal reaction between the settling wheel and the soil N_{rt}. In order to determine the normal reaction of the soil upon the settlement wheel N_{rt}., we write the equilibrium equation of the moments regarding joint O_1, neglecting the rolling resistance moment M_r, (as it is very small), hence it results:

$$N_r = \frac{G_r l_r + G_p l_b + G_s l_s}{l_r} - (R_r + R_{rt})\frac{h_1}{l_r} - -\frac{R_b[(a + h_1) + lRtg\gamma]}{l_r} - \frac{M_l}{l_{12} l_r}(\sin\alpha + \cos\alpha).$$

(1)

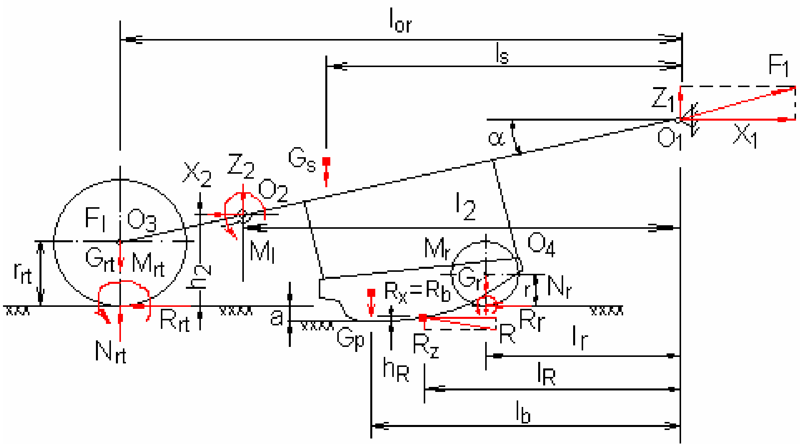

Fig.2. Dynamic model of the seeder unit equipped with the oscillatory bar and adjusting working depth wheel.

It is noticed that the stability of the system on the soil ($N_r \geq 0$) depends both on the advancing resistance of the share that increases with the working depth and tends to rise the oscillatory bar and the elastic moment M_l, which tends to rise the share from the soil.

2. Dynamic and mathematical modeling of the seeder unit with parallelogram mechanism and adjustable settling wheel (Fig. 3)

From the kinematic point of view this type of seeder unit represents a frame on which the settling wheel is fixed (adjustable vertically) and respectively at the other extremity of the skate type share. The frame is tied by means of the tie bars O_1O_3 and respectively O_2O_4 kinematic elements, which are articulated to the seeder frame and at the frame of the seeder unit, thus realizing a deformable parallelogram mechanism. The kinematic elements O_1O_3 and O_2O_4 are of the same length and inclination to the horizontal of the place, defined by angle β. Because the necessary traction force (does not appear on the scheme) is $F_t = X_1 + X_2 = X_3 + X_4$ and in order the section to be rationally caught in the frame of the machine, it is necessary that $X_1 = X_2$ and it results that $X_3 = X_4$ as well. Thus, after transformations, the normal reaction N_r upon the settling wheel becomes:

$$N_r = G_r + \frac{G_s(l_s - l_p) + h_3 F_l \sin\alpha + R_b[(a/3) - (l_p - l_R)tg\gamma] + (1/2)(h_3 + h_4)(R_r + R_b + F_l \sin\alpha)}{l_r - l_p}$$

(2)

It is noticed the dependence of the normal reaction N_r on the elastic force, given by the system of springs, as well as by the resistance to advancing of the share, which, at its turn, depends on the working depth.

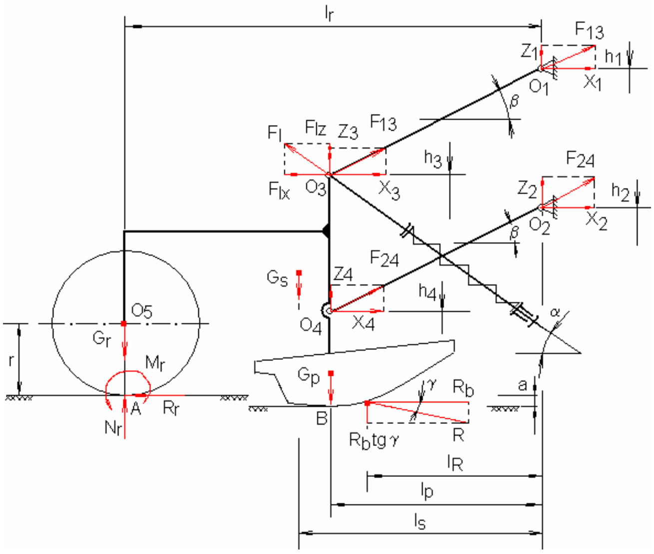

Fig.3. Dynamic model of the of seeder unit with parallelogram mechanism and adjustable settling wheel

3. Dynamic and mathematical modeling of the seeder unit with balance lever

The balance lever type seeder unit with balance lever mechanism (Fig.4) represents a bar supported by two wheels – a wheel in front and the second wheel behind, which in most situations has the role of settling wheel. On the frame of the seeder unit, between the two wheels, there is a skate type share, joined together with it, where at the same time it is articulated both with the tie bar (joint O_5) that serves both to the traction of the section and the spring system that provides a supplementary force, of elastic nature, necessary for increasing the contact pressure between the wheels and the soil – as necessary condition in order to have a continuity of the rolling, that is the constant depth of seeding, as well as the uniform settling of the row of seeds.

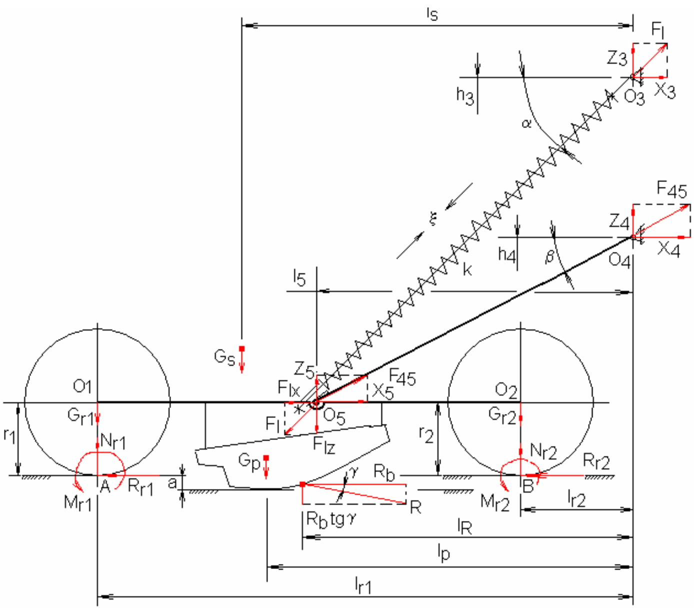

Fig.4. Dynamic model of the seeder unit equipped with the balance lever type.

In order to express the normal reactions of the soil upon the wheels, we write the equilibrium equations of the moments, regarding the contact points between the wheels and the soil *A* and *B* respectively. Thus, after transformations, it results:

$$N_{r2} = G_{r2} + G_s \frac{l_{r1} - l_s}{l_{r1} - l_{r2}} + G_p \frac{l_{r1} - l_p}{l_{r1} - l_{r2}} + F_l \frac{(l_{r1} - l_5)\sin\alpha - r\cos\alpha}{l_{r1} - l_{r2}} -$$

$$- \frac{(R_{r1} + R_{r2} + R_b + F_l \cos\alpha)[tg\gamma(l_{r1} - l_5) - r]}{l_{r1} - l_{r2}} - R_b \frac{tg\gamma(l_{r1} - l_p) - (2/3)a}{l_{r1} - l_{r2}}$$

(3),

whence it results that the normal reaction of the soil upon the front wheel N_{r2} increases together with the force in the spring system and decreases together with the resistance to advancing of the share, respectively the working depth and also decreases when the traction force increases.

Similarly, from the equilibrium equation of the moments regarding contact point *B* ($\sum M_B = 0$) between the front wheel and the soil it is determined by the normal reaction of the soil upon the back wheel N_{r1} ,which in the majority of cases is also the settling wheel:

$$N_{r1} = G_{r1} + G_s \frac{l_s - l_{r2}}{l_{r1} - l_{r2}} + G_p \frac{l_p - l_{r2}}{l_{r1} - l_{r2}} + F_l \frac{(l_5 - l_{r2})\sin\alpha + r\cos\alpha}{l_{r1} - l_{r2}} -$$

$$- \frac{(R_{r1} + R_{r2} + R_b + F_l \cos\alpha)[tg\gamma(l_5 - l_{r2}) + r]}{l_{r1} - l_{r2}} - R \frac{tg\gamma(l_R - l_{r2}) + (2/3)a}{l_{r1} - l_{r2}}$$

(4)

From the above relationship it results that the reaction N_{r1} of the soil upon the settling wheel increases with the weights of the wheel G_{r1} and of the seed box G_s and with own weight of the skate G_p as well with the elastic force F_l in the springs and decreases together with the work resistance R_b of the share (therefore with the seeding depth *a*) and with the traction force transmitted in the articulated tie bars in the couplings O_4 and O_5.

4. Dynamic and mathematical modeling of the seeder unit with oscillatory arm

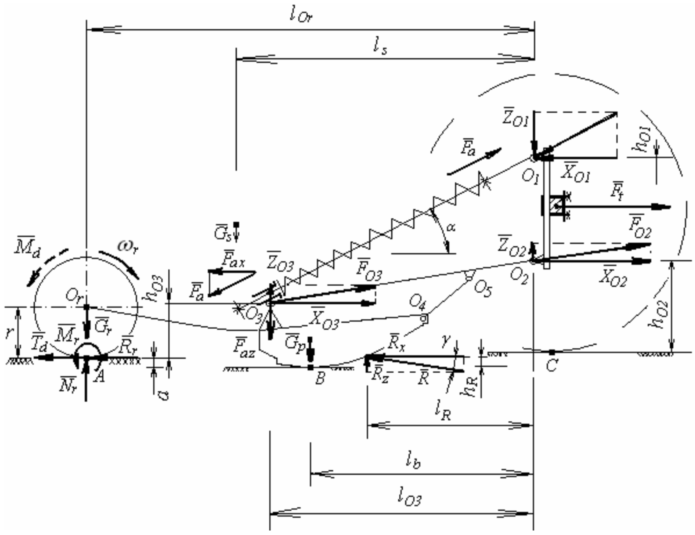

Fig.5. The dynamic model the seeder unit with oscillatory arm

The seeder unit with oscillatory arm represents an arm (bar) articulated in the seeder frame, which oscillates around the articulation point O_2 and is supported by the soil of support (settling) wheel in point *A* (Fig.5). If is neglected the rolling resistance moment M_{r1} of the settling wheel (its values are small) and after transformations in the equilibrium equations, results the reaction on the settling wheel N_r:

$$N_r = \frac{G_r l_{Or} + G_s l_s + G_b l_b + F_a l_{O3} \sin\alpha}{l_{Or} + f \cdot h_{O2}} - \tag{5}$$
$$- \frac{R_b(a - h_R + h_{O2} + l_R tg\gamma) + F_a(h_{O2} - h_{O3})\cos\alpha}{l_{Or} + f \cdot h_{O2}} - \frac{M_d \cdot h_{O2}}{r(l_{Or} + f \cdot h_{O2})}$$

It may be noticed that the first term is positive, so as the forces G_b , G_S, G_r and F_{az} (where $F_{az} = F_a\ sin\alpha$) load the supporting (settling) wheel, and the second term (by the forces R_b, $R_b \cdot tg\gamma$, T_d and F_{ax} (where $F_{ax} = F_a \cos\alpha$) tends to unload this wheel.

CONCLUSIONS

1. From the kinematic point of view, the high precision seeder units may be considered bars mechanisms, sustained on support wheels rolling on soil. In order for the dynamic and mathematical modelling to be carried out, the seeder units must be reduced to particular cases of simple mechanisms.
2. For an efficient operation of seeder units during the working process, it is necessary for the support wheels to permanently stay in contact with the soil. Thus, it is essential to establish the mathematical relations of how the soil acts upon the wheels these units are sustained on.
3. Starting from the mathematical relations that show how the soil acts upon the support wheels of the seeder units, we can analyze the dependence of the soil contact process on the constructive and functional parameters of seeder units.

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