The stability stroke of cotton seeder moulder

To cite this article: F Mamatov *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **883** 012145

IOP Conf. Series: Materials Science and Engineering **883** (2020) 012145 doi:10.1088/1757-899X/883/1/012145

The stability stroke of cotton seeder moulder

F Mamatov[1,2*], B Mirzaev[1], P Berdimuratov[1], Kh Turkmenov[1], L Muratov[1], G Eshchanova[1]

[1]Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Department of hydraulic construction, Tashkent, Uzbekistan
[2]Karshi Engineering Economic Institute, Karshi, Uzbekistan

bahadir.mirzaev@tiiame.uz

Abstract. The stability of moulder stroke affects the uniformity compaction of soil ridge. It depends on the mounting system of molder to the frame and the direction of act-ing forces on them. The aim of the study is to analyze the stability stroke of cot-ton seeder molder. The longitudinal stability of molder in a fixed system of coordinate dependency on acting forces on it, as well as its constructive parameters, have been considered. There has been obtained the equation for the determination of angular deviations of leads of parallelogram fastening system from the initial position under the influence of applied to the moulder forces, constructive parameters of sections, and unevenness of soil surface. It has been established that the fluctuation of links of the parallelogram mechanism is mainly influenced by the weight of mass of moulder system, soil resistance forces, the initial angle of links inclination and force pressure of the spring group. The stability of moulders work is ensured mainly by changing due to the changing force pressure of the spring group.

1. Introduction

It is known that one of the main criteria for assessing the quality of work of machines is the compliance of indicators of technological process, performed by machine with agrotechnical requirements [1]. Therefore, it is important that these indicators have been justified and interconnected sufficiently and mathematically. For this reason, the theoretical issues of stability movement of cotton seeder moulder have been studied by us [2–4].
The aim of the study is to analyze the stability stroke of cotton seeder moulder

2. Methods

The basic principles and methods of classical mechanics, mathematical analysis, and statistics were used in this study.

In the world, a leading role-plays the development and implementation of soil conservation technologies and technical equipment [5–8] in the cultivation of agricultural crops. For avoiding the negative effect of heavy rainfall on seed germination by eliminating the ingress of rain into the seedbed, technology and a special device for a cotton seeder have been developed by us, which simultaneously forms a ridge with a minimum permissible height [2, 9, 10].

The stability stroke of moulder affects the uniformity of soil compaction of the ridge. It depends on the mounting system of moulder to the frame and the direction of acting forces on them (fig. 1). For the moulder a parallelogram fastening system is used. It is known that with such a fastening system, microrelief of field is better copied and the laboring forces are withstood by the given depth molder.

In terms of stability in vertical flatness of laboring forces of cultivators and seed-ers, attached to the parallelogram mounting system, the studies have been conducted by P.T.Babiy [1], P.M. Vasilenko, E.V.Dolmatov [11], P. Dzhumaniyazov [12], K. Irgashev [13], T. Nabiyev [14] and others. It has been established by that the main influence on the stability of the working body is influenced by field relief, section weight, physical and mechanical properties of soil, the angle of inclination of the lead of parallelogram mechanism [15–17].

3. Results and Discussion

During the forward movement of moulder, former, the impact of the following forces on it: gravity *G*, applied at a distance *XG* from the point *O*; force *Q* from the pressure of spring group; horizontal and vertical components of resistance of the moulder Rx and R_z; traction force *P*, applied in parallel to the links of parallelogram suspension. The symmetry form of moulder determines the action of forces on it in one vertical plane.

While considering the stability of the movement of the moulder, it is better to use the calculation method by T.S. Nabiev, which was developed by him for determining the stability of the movement of laboring forces of the cotton cultivator.

Let's consider the longitudinal stability of molder in a fixed coordinate system *XOZ* in the dependence of acting forces on it, as well as its constructive parameters. In this case, let's direct the axis *OX* and *OZ*, shown in Fig. 1.

The coordinates of gravity center X_0 and Z_0 of molder at the initial moment of motion has the following type:

$$\begin{cases} X_0 = X_R + \frac{L_x}{2} - X_G \\ Z_0 = h_\phi + Z_G \end{cases} \quad (1)$$

By the uniform movement of seeder after some time *t*, the seeder moves into the direction of the *OX* axis by the value of $V_n t$. At this time, the molder under the influence of a disturbing moment *M* receives an angular displacement, equal to φ. Then the center of gravity of the section will be moved from the position T (X_0; Z_0) to the position T_1 (X_1; Z_1), coordinates of which are determined by the following expressions:

$$\begin{cases} X_1 = V_П t + X_R + \frac{L_x}{2} - X_G + l\sin\phi_0 - l\sin(\phi_0 + \phi) \\ Z_0 = h_\phi + Z_G + l\cos\phi_0 - l\cos(\phi_0 + \phi) \end{cases} \quad (2)$$

The projection speed of movement of the gravity center of the molder, in this case, is the following:

$$\dot{X}_1 = V_П - l\dot{\varphi}\cos(\varphi_0 + \varphi)$$

$$\dot{Z}_1 = l\dot{\varphi}\sin(\varphi_0 + \varphi) \quad (3)$$

Under the condition V_p = const the system will have one degree of ease.

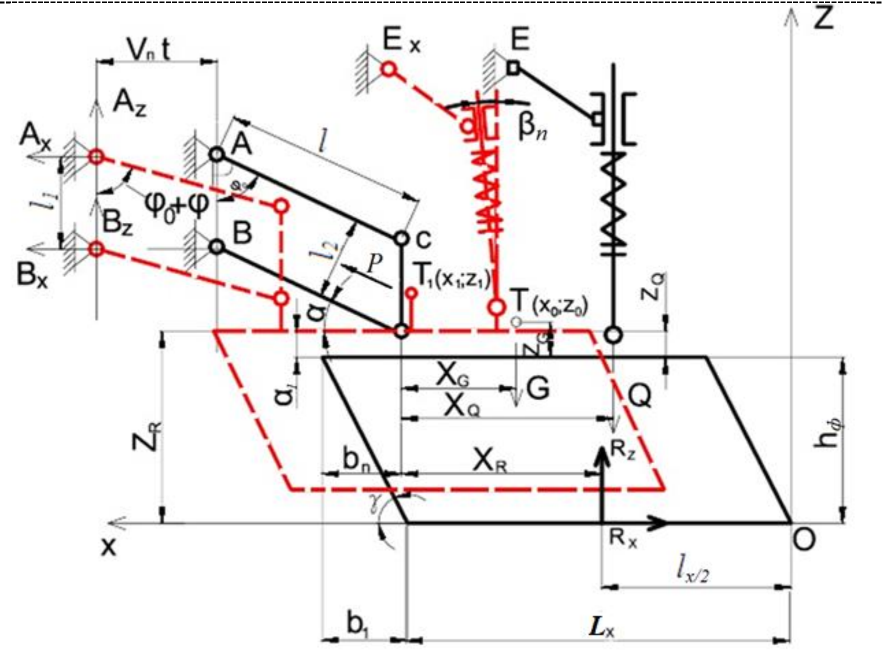

Figure 1. Scheme of molder section stroke under the influence of acting forces

Let's take for the generalized coordinate of angular stroke of φ links of the parallelogram mechanism of moulder section. In this case, the problem of stability stroke is reduced to the determination of φ as a function of time. To compose the differential equation of motion of the molder, the second type of Lagrange equation is used, which has the following form [12–14].

$$\frac{d}{dt}\left(\frac{dT}{d\dot{\phi}}\right)-\frac{dT}{d\phi}+\frac{d\Pi}{d\phi}=Q_{\phi} \tag{4}$$

here: T is the kinetic energy of the system;
P is the potential energy of the spring group of the regulator, deepening moulder;
Q_φ is the generalized force.
The kinetic energy of this system is determined by the well-known equation

$$T=\frac{1}{2}mV^2+\frac{1}{2}J_0\dot{\phi}^2 \tag{5}$$

here: m is the mass of molder section; V is the translational speed of center gravity of the molder; J_0 is moment of inertia of the molder section relative to the axis, passing through the center of gravity perpendicular to the longitudinally vertical flatness.
Taking into account the values $V^2=\dot{X}_1^2+\dot{Z}_1^2$ of X_1 and Z_1 from equations (3) by T.S.Nabiev, there has been obtained the following:

$$T=\frac{1}{2}m\left[V_{\Pi}^2-2V_{\Pi}l\dot{\varphi}\cos(\varphi_0+\varphi)+l^2\cdot\dot{\varphi}^2\right]+\frac{1}{2}J_0\cdot\dot{\varphi}^2, \tag{6}$$

$$\frac{dT}{d\dot{\varphi}}=mV_{\Pi}l\dot{\varphi}\sin(\varphi_0+\varphi), \tag{7}$$

$$\frac{d}{dt}\left(\frac{dT}{d\dot{\varphi}}\right)=m\left[V_{\Pi}l\dot{\varphi}\sin(\varphi_0+\varphi)+l^2\ddot{\varphi}\right]+J_0\cdot\ddot{\varphi}. \tag{8}$$

The potential energy of the spring group is determined by the following dependency[14]:

$$\Pi = \frac{Z\Delta l^2}{2} \tag{9}$$

here: z is the stiffness of spring group; Δl is the value of spring deformation when the section deviates from the initial position.
The value of Δl is determined by the following expression [14]:

$$\Delta l = l_Q \varphi. \tag{10}$$

Here

$$\frac{d\Pi}{d\varphi} = Z l_Q^2 \varphi. \tag{11}$$

Then, after substituting the values of kinematic and potential energies in equation (4) and simplification there has been obtained [14]:

$$J_n \ddot{\varphi} + Z l^2 \varphi = Q_\varphi, \tag{12}$$

here: $J_n = ml^2 + J_0$.

For the determination of the generalized force Q_ϕ it the equation of virtual work of forces, applied to laboring forces was used by T.S. Nabiev [14]:

$$M\delta\phi = Q_\phi \delta\phi \tag{13}$$

here M=Q_φ, where M is the total (disturbing) moment of forces, applied to laboring forces relative to the point of attachment to the frame of the seeder.
From Fig. 1, it is obvious that

$$\begin{aligned} M = {} & R_x\left[l\cos(\phi_o+\phi)+h_\phi+a_1\right]-R_Z\left[l\sin(\phi_o+\phi)+\frac{L}{2}+b_1-b_n\right]- \\ & -G\left[l\sin(\phi_o+\phi)+X_G\right]+Q\cos\beta\left[l\sin(\phi_o+\phi)+X_G\right]+ \\ & +Q\sin\beta\left[a-Z_Q+l\cos(\phi_o+\phi)\right]+A_x l_1 \end{aligned} \tag{14}$$

here R_x and R_Z sre the horizontal and vertical components of moulder resistance; l is the length of the longitudinal links of the parallelogram mechanism;
hf is the depth of moulder; β is the angle of inclination of the leash;
G is the weight of molder section; A_x is the horizontal component of the reaction of the upper hinge A_x of attachment of the parallelogram mechanism to the frame of the seeder.

The reaction A_x can be expressed in terms of the known forces R_x, R_z, G, and Q.

From the equilibrium condition, the following is obtained:

$$A_z + B_z - G - Q - R_z = 0,$$

$$A_x + B_x - R_x = 0.$$

Assuming $A_z = B_z$ and $A_x = B_x$, the following is obtained:

$$2A_z - G - Q - R_z = 0$$

$$2A_x - R_x = 0,$$

from here

$$A_z = \frac{G+Q+R_z}{2}; \quad A_x = \frac{R_x}{2} \tag{15}$$

It is known that the depth of the moulder hf, including the moulder varies depending on the profile of soil surface, but this dependence can be written in the following form [14]:

$$h_t = h_o\left[1 + (\eta - 1)Cos\rho t\right], \quad (16)$$

$$\rho = \frac{2\pi}{T} \quad V_{\Pi}T = S, \quad \eta = \frac{h_{\max}}{h_0} \geq 1$$

here: h_{max} is the maximum value of the depth of moulder; h_0 – is the average value of stroke depth; ρ-is the frequency of fluctuations in the roughness of the soil surface; T is the period of fluctuation; V_p is the speed of aggregate moat he unit. It is known [14], that for $\eta=1$, $h_t=const=h_0$

Taking into account expressions (15) and (16), and after some simplifications, equation (14) can be written in the following form:

$$M = \left(R_x l\cos\phi_o - R_z l\sin\phi_o - Gl\sin\phi_o - Ql\cos\beta\sin\phi_o + Ql\sin\beta\cos\phi_o\right)\cos\phi -$$
$$-\left(R_x l\sin\phi_o + R_z l\cos\phi_o + Gl\cos\phi_o + Q\cos\beta l\cos\phi_o + Q\sin\beta l\sin\phi_o\right)\sin\phi + \quad (17)$$
$$+\left\{R_x Z_k + R_x h_o\left[1+(\eta-1)\cos\rho t\right] - R_x a - R_z\left(\frac{L}{2} + b_1 + b_n - GX_G + QX_a + Q\sin\beta\left(a - Z_Q\right) + A_x l_1\right\}$$

For the simplification (17) let us use the method by T.S. Nabiev and then introduce the following expressions:

$$A_1 = R_x l\cos\varphi_o - R_z l\sin\varphi_o - Gl\sin\varphi_o - Ql\cos\beta\sin\varphi_o + Ql\sin\beta\cos\varphi_o;$$
$$A_z = R_x l\sin\varphi_o + R_z l\cos\varphi_o + Gl\cos\varphi_o + Ql\cos\beta\cos\varphi_o + Ql\sin\beta\sin\varphi_o;$$
$$A_3 = R_x Z_k + R_x h_o\left[1+(\eta-1)\cos\rho t\right] - R_x a - R_z\left(\frac{L}{2} + b_1 - b_n\right) - GX_G + QX_Q + Q\sin\beta\left(a - Z_Q\right) + A_x l_1.$$

Then (17), it is given in the form

$$M = A_1\cos\varphi - A_2\sin\varphi + A_3 \quad (18)$$

After substituting the value of the disturbing moment M in equation (12), it is possible to obtain:

$$J_n\ddot{\varphi} = A_1\cos\varphi - A_2\sin\varphi - zl_a^2\varphi + A_3 \quad (19)$$

After integrating equation (19) and several mathematical transformations by T.S.Nabiev, it has been obtained the following dependence for determining the angular movement φ.

$$\varphi = \frac{A_1 + A_3}{A_2 + zl_a^2}\left(1 - \cos\sqrt{\frac{A_2 + zl_a^2}{J_n}}\,t\right) \quad (20)$$

The deviations of longitudinal links of the parallelogram mechanism of the seeder moulder from the initial position for given perturbing forces occur according to (20).

Substituting the values A_1, A_2 and A_3, and in equation (20) we have

$$\phi = \frac{R_x\left[l\cos\phi_0 + Z_k + h_0\left(1+(\eta-1)\cos\rho t\right)-a\right] - R_z\left[l\sin\phi_0 + \frac{L}{2} + b_1 + b_n\right] -}{l\left[R_x\sin\phi_0 + R_z\cos\phi_0 + G\cos\phi_0 + Q\cos\left(\beta-\phi_0\right)\right] +}$$

$$\frac{-G\left[l\sin\phi_0 + X_G\right] - Q\left[l\sin\left(\beta-\phi_0\right) + X_a - \sin\beta\left(a - Z_a\right)\right] + A_x a_1}{+zl_a^2}\times \qquad (21)$$

$$\times\left[1-\cos\sqrt{\frac{l\left[R_x\sin\phi_0 + R_z\cos\phi_0 + G\cos\phi_0 + Q\cos\left(\beta-\phi_0\right)\right] + zl_a^2}{J_n}}t\right]$$

The equation (21) shows the dependence between angular deviations of leads from the initial position under the actions, applied to the moulder forces, structural parameters of section, and the unevenness of soil surface.

The analysis of equation (21) shows that the value φ is mainly influenced by the weight *G* to the mass of the system, soil resistance forces, angle of inclination of links, and the force *Q* of spring group pressure. The increases of pressure in the spring group lead to a decrease in the amplitude of fluctuations of the parallelogram mechanism of moulder.

Thus, a stable stroke of moulder can be achieved by changing forces of spring group pressure and angle of inclination of links. In practice, the stability of moulder stroke is ensured mainly by changing forces of spring pressure depending on working conditions.

4. Conclusions

1. The obtained equation of fluctuation has shown that the fluctuation of links of the parallelogram mechanism is mainly influenced by the weight of the mass system of the moulder, force of soil resistance, the initial angle of inclination of links, and force pressure of spring group.
2. The stability of moulder work is ensured mainly by changing the force pressure of the spring group.

References

[1] Vasilenko P M 1961 *Cultivators*
[2] Aldoshin N Didmanidze O Mirzaev B 2019 Harvesting of mixed crops by axial rotary combines. *Proceeding of 7th International Conference on Trends in Agricultural Engineering* pp 20–26
[3] Mamatov F Mirzaev B Shoumarova M Berdimuratov P 2009 Comb former parameters for a cotton seeder *Int. J. Eng. Adv. Technol* **9** pp 4824–4826
[4] 1973 P F F *Handbook on Higher Mathematics* (Kiev)
[5] Mirzaev B Mamatov F Avazov I Mardonov Sh 2019 Technologies and technical means for anti-erosion differentiated soil treatment system *E3S Web of Conferences* **97**
[6] Mirzaev B Mamatov F Ergashev I Ravshanov H Mirzaxodjaev Sh Kurbanov Sh 2019 Effect of fragmentation and pacing at spot ploughing on dry soils. *E3S Web of Conferences* **97**
[7] Mirzaev B Mamatov F 2019 A justification of broach-plow's parameters of the ridge-stepped ploughing *E3S Web of Conferences* **97**
[8] Mirzaev B Mamatov F Chuyanov D Ravshanov X Shodmonov G Tavashov R Combined machine for preparing soil for cropping of melons and gourds *XII Int. Sci. Conf. Agric. Mach. Ind*.
[9] Berdimuratov P T 2018 Improving the combing technology and tool for sowing the cotton. *Eur. Sci. Rev*. pp 237–239

[10] Mirzaev B Mamatov F Aldoshin N 2019 Anti-erosion two-stage tillage by ripper *Proceeding 7th Int. Conf. Trends Agric. Eng*. pp 391–396
[11] 1970 E V D The influence of parameters of the suspension mechanism of the working bodies of cultivators on the stability of their course in depth *Trans. VIM* **62** pp 143–146
[12] 1969 P D Some questions are the study of a four-link mechanism / with elastic coupling / cotton cultivator
[13] 1964 K I The study of working bodies of the cultivator for processing the protective zones of cotton rows
[14] 1975 T S Strengthening of concrete beams using innovative ductile fiber- fiber reinforced polymer fabric
[15] Utepbergenov B K Berdimuratov P T 2017 Justification of optimal parameters of beds for sowing cotton on their ridges. Bull. *Karakalpak branch Acad. Sci. Repub. Uzb* **246** pp 34–36
[16] 1962 V M The study of the opener system of sowing machines in soil woodland conditions
[17] 1971 Ya G Introduction to the theory of mechanical vibrations