ISSN NO: 2771-8840
October 2025

Investigation of the Depth Stability of the Furrow Former of a Saxaul Seed Planter

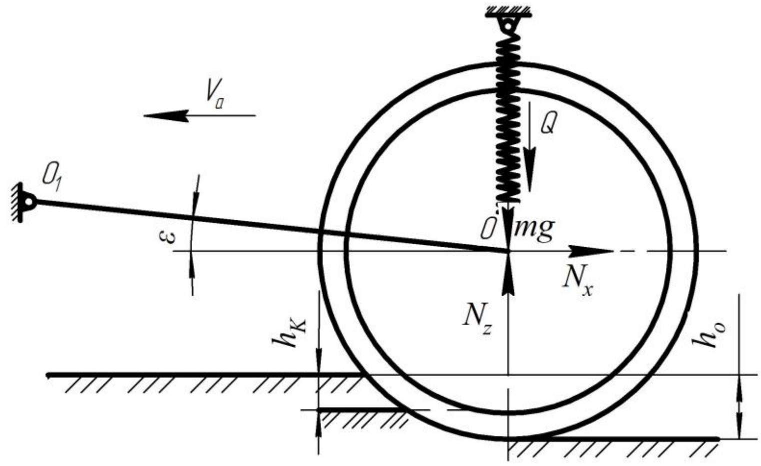
Auyezov Ongarbay Pirleshovich, Doctor of Technical Sciences, Professor;
Baltaniyazov Adilbay Sarsenbayevich
Tursımuratov Sapar Eshmuratovich, PhD in Technical Sciences;
KhojabaevNurmukhambet Muratbaevich, Basic Doctoral Student.

Abstract
The article presents analytical expressions for determining the depth stability of the furrow former of a saxaul seed planter and identifies the factors that influence its performance.

Keywords: Saxaul seed planter

The **oval roller** is connected to the seeder frame through a **parallelogram mechanism**. Therefore, as shown in **Figure 1**, all the forces acting on it can be considered as applied to the lower movable hinge **O** of the parallelogram mechanism [1, pp. 118–120].
During operation, due to the **irregularities of the field surface** and the **variable physical and mechanical properties of the soil**, the normal force **N** acting on the working body and its horizontal (**Nx**) and vertical (**Nz**) components change continuously. As a result, the working body oscillates relative to the lower fixed hinge **O_1** of the parallelogram mechanism. This, in turn, leads to changes in the penetration depth of the working body into the soil and causes the furrow to form unevenly.
Therefore, the **amplitude of the oscillations** of the working body relative to the hinge **O_1** should be kept as small as possible. To address this problem, we derive and solve the **differential equation** describing the oscillations of the working body relative to the hinge **O_1**. For this purpose, the following assumptions are made [2, pp. 105–108]:
- The aggregate moves **in a straight line at a constant speed**;
- The **friction force** at the hinge **O_1** is small and has no significant influence on the oscillations of the working body;
- In its equilibrium state, the **lower longitudinal link** of the parallelogram mechanism is **horizontal** and, during operation, deviates from this position by only a **small angle**.

We take as the **generalized coordinate** the **deflection angle ε** of the lower longitudinal link of the parallelogram mechanism from the horizontal.



1 – roller; 2 – oval

Figure 1. Diagram for studying the stability of the oval roller's penetration depth into the soil
Using the equation of rotation of a rigid body about a fixed axis [3, pp. 279–280], we write:

$$J\frac{d^2\varepsilon}{dt^2} = (N_z - Q - mg)l_n \cos\varepsilon - N_x l_n \sin\varepsilon, \tag{1}$$

ISSN NO: 2771-8840
October 2025

Where
J – moment of inertia of the oval roller relative to the rotation axis **O**, kg·m²;
Q – spring pressure force, N;
m – mass of the roller, kg;
g – acceleration due to gravity, m/s²;
$\mathbf{l_n}$ – length of the longitudinal link of the seeder's parallelogram mechanism, m.
Since the oscillation angle **ε** is small, we assume **sin ε ≈ ε** and **cos ε ≈ 1**.
Taking this into account, equation (1) takes the following form:

$$J\frac{d^2\varepsilon}{dt^2} = (N_z - Q - mg)l_n - N_x l_n \varepsilon. \quad (2)$$

We consider the soil **reaction force** N_z acting on the working body to consist of the **elastic component** N_y and the **resistance component** N_o , which depend on the **vertical displacement** and the **velocity** of this displacement, as well as the **variable force** N_t arising from **field surface irregularities** and the **changing physical and mechanical properties of the soil** [4, p. 230; 3, p. 58].
In this case —

$$N_z = N_y + N_o + N_t. \quad (3)$$

We substitute equation **(3)** into equation **(2)**:

$$J\frac{d^2\varepsilon}{dt^2} = (N_y + N_o + N_t - Q - mg)l_n - N_x l_n \varepsilon. \quad (4)$$

When the working body is in a **static equilibrium state**:

$$N_y = h_o C_n b; \quad (5)$$

$$N_o = 0; \quad (6)$$

$$Q = Q_0; \quad (7)$$

$$N_t = 0, \quad (8)$$

where
$\mathbf{C_n}$ – stiffness coefficient of the soil per unit working width of the implement, N/m²;
$\mathbf{b = B_x}$ – working width of the implement, m;
$\mathbf{Q_0}$ – initial compression force of the spring, N.
When the **parallelogram link** deviates from its equilibrium position by an angle **ε** —

$$N_y = (h_o - l_n \varepsilon)C_n b; \quad (9)$$

$$N_o = -b_n b l_n \frac{d\varepsilon}{dt}; \quad (10)$$

$$N_t = \Delta R_z(t) \quad (11)$$

and

$$Q = Q_0 + C_n l_n \varepsilon, \quad (12)$$

where
$\mathbf{b_n}$ – resistance coefficient of the soil per unit working width of the implement, N·s/m²;
$\mathbf{C_n}$ – stiffness coefficient of the spring.
If we substitute the values of $\mathbf{N_\gamma}$, $\mathbf{N_o}$, $\mathbf{N_t}$, and **Q** according to expressions (9)–(12) into equation (4), we obtain:

$$J\frac{d^2\varepsilon}{dt^2}=\left[(h_o-l_n\varepsilon)C_nb-b_nbl_n\frac{d\varepsilon}{dt}+\Delta R_z(t)-(Q_0+C_nl_n\varepsilon)-mg\right]l_n-N_xl_n\varepsilon. \quad (13)$$

When the working body is in **static equilibrium**:

$$(h_oC_nb-Q_0-mg)l_n=0. \quad (14)$$

Taking (14) into account, equation (13) takes the following form:

$$J\frac{d^2\varepsilon}{dt^2}=\Delta R_z(t)l_n-C_nbl_n^{\,2}\varepsilon-C_nl_n^{\,2}\varepsilon-b_nbl_n^{\,2}\frac{d\varepsilon}{dt}-N_xl_n\varepsilon \quad (15)$$

or

$$J\frac{d^2\varepsilon}{dt^2}+b_nbl_n^{\,2}\frac{d\varepsilon}{dt}+(N_x+C_nbl_n+C_nl_n)l_n\varepsilon=\Delta R_z(t)l_n. \quad (16)$$

Since the force N_x is variable, this equation is a **second-order differential equation with variable coefficients**.

From the **theory of vibrations**, it is known [5, pp. 110–112] that a system described by equation (16) may, in theory, exhibit **parametric vibrations**. However, because the soil has a **high damping capacity**, **parametric vibrations** of the working body are not observed. It mainly undergoes **forced oscillations** under the influence of the external force $\Delta R^z(t)$.

Taking this into account, we assume that the force R_x is **constant** and equal to its **average value**, and we consider the **forced oscillations** of the working body under the action of the force $\Delta R^z(t)$. Here we assume that the force $\Delta R^z(t)$ varies according to a **sinusoidal law**, that is —

$$\Delta R_z(t)=\Delta R\sin\omega t, \quad (17)$$

Where

ΔR – amplitude of the variable force, N;

ω – frequency of the variable force, 1/s.

Substituting equation **(17)** into equation **(16)**, we write:

$$J\frac{d^2\varepsilon}{dt^2}+b_nbl_n^{\,2}\frac{d\varepsilon}{dt}+(N_x+C_nbl_n+C_nl_n)l_n\varepsilon=\Delta Rl_n\sin\omega t \quad (18)$$

or

$$\frac{d^2\varepsilon}{dt^2}+2n\frac{d\varepsilon}{dt}+k^2\varepsilon=H\sin\omega t, \quad (19)$$

where

$$n=\frac{b_nbl_n^{\,2}}{2J};\quad k=\sqrt{\frac{(N_x+C_nbl_n+C_nl_n)l_n}{J}}\ \text{ва}\ \ H=\frac{\Delta Rl_n}{J}.$$

It is known [6, p. 281] that the solution of equation **(19)**, which describes the **forced oscillations of the working body**, is as follows:

$$\varepsilon(t)=\frac{H}{\sqrt{(k^2-\omega^2)^2+4n^2\omega^2}}\sin(\omega t-\Delta) \quad (20)$$

or, taking into account the adopted notations

$$\varepsilon(t)=\frac{\Delta Rl_n\sin(\omega t-\Delta)}{J\sqrt{\left[\frac{(N_x+C_nbl_n+C_nl_n)l_n}{J}-\omega^2\right]^2+\left(\frac{b_nbl_n^{\,2}}{J}\right)^2\omega^2}}, \quad (21)$$

ISSN NO: 2771-8840
October 2025

where

$$\Delta = arctg\frac{b_n b l_n^2 \omega}{(N_x + C_n b l_n + C_n l_n) l_n - J\omega^2}.$$

The **maximum deflection angle** of the longitudinal link from its equilibrium position, according to equation **(21)**, is equal to:

$$\varepsilon_{\max} = \frac{\Delta R l_n}{J\sqrt{\left[\frac{(N_x + C_n b l_n + C_n l_n) l_n}{J} - \omega^2\right]^2 + \left(\frac{b_n b l_n^2}{J}\right)^2 \omega^2}}. \quad (22)$$

Expressions **(21)** and **(22)** show that the **stability of the working body in furrow formation**, and therefore the **quality of the furrow**, depends on the **moment of inertia of the roller**, the **length of the longitudinal link of the seeder**, the **spring pressure force of the parallelogram mechanism**, the **amplitude and frequency of the variable force**, as well as the **physical and mechanical properties of the soil**. Under the given working conditions and specific parameter values, the required stability of the working body in forming the furrow can mainly be ensured by the **proper selection of the spring pressure force** of the parallelogram mechanism.

References

1. Klenin N.I., Sakun V.A. *Agricultural and Reclamation Machines.* Moscow, 1980. – 656 p.
2. Ibragimov A. *Study of Angular Vibrations of a Seeder Press Roller for Sowing Small-Seed Crops.* Problems of Mechanics. – Tashkent, 2009. No. 5–6. pp. 105–108.
3. Butenin N.V., Lunts Ya.L., Merkin D.R. *Course of Theoretical Mechanics. Vol. 2: Dynamics (3rd revised edition).* Moscow: Nauka, 1985. – 309 p.
4. Tukhtakuziyev A. *Mechanical and Technological Foundations for Improving the Efficiency of Soil-Cultivating Machines in the Cotton-Growing Complex.* Doctoral dissertation. Yangiyul: UzMEI, 1998. – 336 p.
5. Vulfson I.I. *Vibrations of Machines with Cyclic Mechanisms.* Leningrad: Mashinostroenie, Leningrad Branch, 1990. – 309 p.
6. Gernet M.M. *Course of Theoretical Mechanics.* Moscow: Vysshaya Shkola, 1981. – 304 p.
7.

Authors

Auyezov Ongarbay Pirleshovich
Doctor of Technical Sciences, Professor, Department of “Mechanization of Agriculture”
Karakalpak Agricultural and Agrotechnological Institute
230109, Nukus, Abdambetov St., No. 21
Tel.: (home) 224-34-58, (mobile) +99891 389 49 21
Baltaniyazov Adilbay Sarsenbayevich
Doctor of Philosophy (PhD) in Technical Sciences, Department of
“Mechanization of Agriculture”
Karakalpak Agricultural and Agrotechnological Institute
230109, Nukus, Abdambetov St.
Tel.: (home) 55 104-39-30, (mobile) +99899 420 10 39
Tursımuratov Sapar Eshmuratovich
Doctor of Philosophy (PhD) in Technical Sciences, Department of
“Mechanization of Agriculture”
Karakalpak Agricultural and Agrotechnological Institute
230109, Nukus, Abdambetov St.
Tel.: (home) 55 104-41-16, (mobile) +99893 614 40 20
KhojabaevNurmukhambet Muratbaevich
Basic Doctoral Student (3rd year), Department of “Mechanization of

ISSN NO: 2771-8840
October 2025

Agriculture”
Karakalpak Agricultural and Agrotechnological Institute
230109, Nukus, Abdambetov St.
Mobile: +99890 706 76 10