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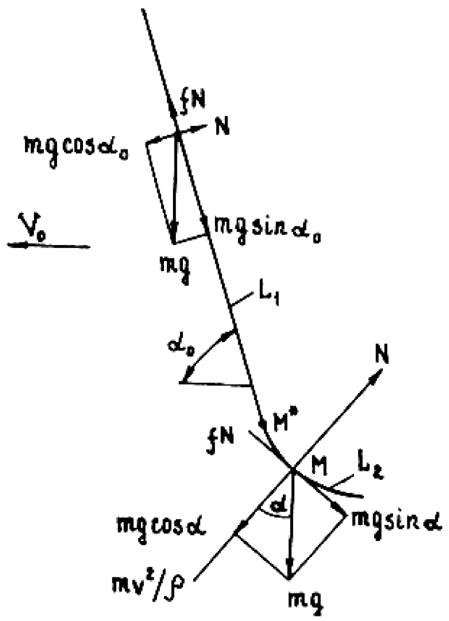
Determination of Seed Cable Parameters

Gaybullaev Zayniddin Xayriyevich
Associate Professor of the Department of Mechanics, Bukhara Engineering and Technological Institute, Republic of Uzbekistan, Bukhara

Azizov Bakhtiyor Abduvaxitovich
Senior Lecturer, Bukhara Engineering Technological Institute, Republic of Uzbekistan, Bukhara

We consider the question of determining the parameters of the profile line of the seed tube allowing to achieve a predetermined speed of the seed in the machines of its release. The uniformity of seed distribution along the row depends not only on the quality of the sowing machine, but also on other factors, including the rolling of the seeds along the bottom of the furrow and their reflection from it, i.e. from the horizontal and vertical components of the speed of the seed at the time of its fall to the bottom of the furrow. The horizontal component of the absolute speed of the seed at the moment of its departure from the sowing unit is close to the forward speed of the sowing unit due to the small relative speed of the seed. From the above it follows that during sowing there is a significant distortion of the parameters of the initial flow of seeds formed by the seeding device. This leads to large disturbances in the uniformity of seed distribution along the row. In double-disc planters, seeds are directed from the sowing unit to the bottom of the furrow through a saber-shaped seed tube. This allows each seed to follow the same trajectory defined by the profile curve of the seed tube. The selection criterion is as follows: when leaving the seed tube, the speed of the seed in its relative movement should be directed opposite to the forward speed of the machine; the absolute value of the aforementioned relative speed should be sufficient in order to reduce the portable, i.e. acquired due to the movement with the machine, the speed of the seeds, that their rolling along the bottom of the furrow is excluded. Below we consider the question of choosing a profile curve that satisfies the formulated criterion [3]. Any movable coordinate system rigidly connected with the vas deferens can be considered with a high degree of accuracy, inertial, as a result of which the movement of the seed in relation to it (in particular, its movement in the vas deferens) is described in the same way as its movement relative to the stationary frame of reference. The linear dimensions of the seed are negligible compared to the distances traveled by it in the vas deferens. From this it follows that the movement of the seed in the vas deferens can be described, with sufficient for practical purposes accuracy, as the movement of a material point along the line of intersection L of the inner surface of the vas deferens with its plane of symmetry.



forces acting on the seed when it moves in the seed tube

Let $\vec{V}_0$ - be the average speed of the seeder during its working process; m is the mass of the seed; m - point of line M_t, which determines the position of the seed at time t; $\vec{g}$ – acceleration of gravity; К – is an arbitrarily chosen coordinate system, which is motionless relative to the vas deferens; O - its origin;

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$\vec{r}(t) = \overrightarrow{OM_t}$ is the vector function given by the equality r ⃗ 〖(t) = (OM) ⃗〗 _t, as a result of which the vector parametric equation of the curve L in the coordinate system K can be represented as $\vec{r} = \vec{r}$ (t) (function $\vec{r}$(t) has continuous derivatives of the first and second orders for all t; we will assume that $\vec{r} \neq 0$ for any t); $\vec{v} = \vec{v}$(t) = $\vec{r}$; M_0 - the beginning of the trajectory of the point M_t: $s = s(t) -$ the length of the arc M_0 , M_t of the curve L; $\tau = \tau_t$ and $\vec{\vartheta} = \vec{\vartheta}(t)$ are the single vectors of the tangent and normal to the line L at the point k M_b ; k = k(s) – is the curvature of the trajectory L at a point whose curvilinear abscissa is equal to s; ρ = 1/k ; $\vec{F}$ - the main vector of the system of active forces acting on the seed during its movement in the vas deferens; N - is the absolute value of the force of normal pressure of the seed on the inner surface of the vas deferens; $\vec{R}$ - is the main vector of the system of dissipative forces applied to the seed during its movement along the line L; ƒ – coefficient of friction of the seed on the inner surface of the seed tube. The functions $\vec{\tau}, \vec{v}$ and can also be expressed in terms of S. In this case, we will write τ ⃗ $\vec{\tau}$(s), $\vec{v}$(s) and $\vec{v}$(s). Due to the introduction of the natural parameter s, the directions of the vectors $\vec{\tau}$ and $\vec{v}$ are uniquely determined by equality.

$\vec{\tau}$ = d$\vec{r}$ / ds and the first Frenet formula $\vec{v} = \rho(d\vec{r}/ds)$ In what follows, it will be clear from the context whether t or s is considered the independent variable.

As the frame of reference K we take the rectangular coordinate system OXY lying in the plane of the trajectory L. Its origin 0 is aligned with point M_0, the ray (oyt) is directed vertically downward, and the positive direction of the abscissa axis is chosen so that line L lies in the first coordinate quarter. We put

$\alpha = \alpha(s)$. Then (figure) $\vec{g}$ = g$(\sin\alpha\vec{\tau}v - \cos\alpha\vec{\gamma})$. (1)

Due to the inertia of the frame of reference K and the theorem on the liberation of the mechanical system from the constraints imposed on it, the equation of the relative motion of the seed will be

m $\vec{r} = \vec{F} + N\vec{v} + \vec{R}$, (2)

moreover

$\ddot{\vec{r}} = \frac{d}{dt}(v\,\vec{\tau}) = \dot{v}\,\vec{\tau} + \frac{v^2}{\rho}\,\vec{v}$; (3)

$\vec{F} = m\,\vec{g}$; (4)

Where $\vartheta\frac{d\vec{\tau}}{dt} = \vartheta\frac{\vartheta}{\rho}\vec{\gamma}$ $\qquad \vec{R} = -\mathfrak{f}\,N\,\vec{\tau}$ (5)

Based on *(1)…(5)*

$m\,\dot{v}\,\vec{\tau} + \frac{m\,v^2}{\rho}\vec{\gamma} = mg\,(\sin\alpha\,\vec{\tau} - \cos\alpha\vec{\gamma}) + N\,\vec{\gamma} - \mathfrak{f}\,N\,\vec{\tau}$. (6)

From (6) and the linear independence of the vectors $\vec{\tau}$ and $\vec{v}$ it follows that

what [2]

$m\,\dot{v} = mg\sin\alpha - \mathfrak{f}\,N$; (7)

$\frac{m\,v^2}{\rho} = -\,mg\cos\alpha + N$. (8)

The exclusion of the normal reaction N from (7) and (8) leads to the equation [2]:

$\dot{v} + \mathfrak{f}\,\frac{v^2}{\rho} = g\,(\sin\alpha - \mathfrak{f}\cos\,\alpha)$. (9)

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The second term on the left-hand side of (9) can also be represented as $ƒ k v^2$

Let the seed tube be made so that the upper part L_1 of the line L - is a straight line segment, and the lower part is an arc of a curve, and at their common point M the function $\vec{\tau}$ (s) is continuous, α (s) has a continuous first-order derivative, and k(s) undergoes a break of the first kind. Then the equality α = α_0 = const, k = 0 holds along L_1 as a result of which (2.9) takes the form $\alpha = \alpha_0 = const,\ k = 0,$ that is,

$$\ddot{s} = \frac{\sin(\alpha_0 - \varphi)}{\cos\varphi}\, g\,,\ \ \varphi = arctg\ ƒ\ . \qquad (10)$$

The initial conditions will be

$$S\,(0) = 0\ ,\ \ \dot{s}(0) = v_0\ . \qquad (11)$$

By virtue of (10) and (11), integrating this formula twice, we obtained

$$S = v_0 t + \frac{\sin(\alpha_0 - \varphi)}{2\cos\varphi}\, g\, t^2\ . \qquad (12)$$

To describe the movement of the seed along the lower part of the vas deferens, we represent (9) c. form [2]:

$$\frac{dv^2}{ds} + \frac{2ƒ}{\rho}\, v^2 = 2g\,(\sin\alpha - ƒ\cos\alpha)\,, \qquad (13)$$

Where

$$v^2 = \varrho^{-2\int\frac{ds}{\rho}} \left[\!\left[\, \mathcal{L} + 2g \int(\sin\alpha - ƒ\cos\alpha)\, l^{2f\int\frac{ds}{\rho}}\, ds \right]\!\right]\,, \qquad (14)$$

Where L is the constant of integration.

According to the definition of curvature, $d\,\alpha\,/\,d\,s = k$. Hence, up to a constant term,

$$\int\frac{ds}{\rho} = \alpha\,(s)\ . \qquad (15)$$

It follows from (14) and (15) that

$$v^2 = e^{-2ƒ\alpha}\left[L + 2g \int l^{2ƒ\alpha}(\sin\alpha - ƒ\cos\alpha)\, ds\right]. \qquad (16)$$

Let L_2 be an arc of a circle of radius and length R. then

$$S = R\,\alpha\ . \qquad (17)$$

Based on (16) and (17)

$$v^2 = Le^{-2ƒ\alpha} + \frac{2Rg}{1+4ƒ^2}\left[ƒ\sin\alpha - (1 + 2ƒ^2)\cos\alpha\right]. \qquad (18)$$

(eighteen)

By virtue of (18) and the initial condition $v\big|_{\alpha = \alpha_0} = v_0$

$$v^2 = \left\{v_0^2 - \frac{2Rg}{1+4ƒ^2}\left[ƒ\sin\alpha_0 - (1 + 2ƒ^2)\cos\alpha_0\right]\right\} \int l^{2ƒ(\alpha_0 - \alpha)} +$$

$$+ \frac{2Rq}{1+4ƒ^2}\left[ƒ\sin\alpha - (1 + 2ƒ^2)\cos\alpha\right]. \qquad (19)$$

Using formula (19), the parameters of the line L can be determined, which make it possible to achieve a predetermined seed speed at the time of its exit from the seed tube. Let $\triangle$ be the difference between the speed of the seeder and the horizontal component of the relative speed v ⃗ of the seed at the above moment. If $V_0 \leq 1м/с$, the height of the seed falling to the bottom of the furrow does not exceed 2 cm, then there is practically no redistribution of seeds in the row. Let $\overrightarrow{v^*}$ - be the speed (in the frame of reference K) of the release of the seed from the seed tube. If $v^* = 2.5$ м/с and $6km/ч \leq V_0 \leq 12$ км/ч (т.е. 1,67 $м/с \leq V_0 \leq$ 3,33 $м/с$), then $0 \leq \triangle v \leq 0{,}83$ m / s, and the relative velocity $\overrightarrow{V_0}$, for $v^* >$ 2.5 m/s is opposite to the vector (V_0) ⃗, and for $v^* = 2.5$m/s - it is co-directed to it. Calculations made according to formulas (12) and (19) show that the required relative velocity v ^ * = 2.5 m / s is achieved at α_0 = 75^o; segment length L equal to 480mm; ƒ = 0,3; ρ = 60мм; $\alpha = 0$ at the lower end of the arc L_2 References.

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