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Productivity of screw working together with the planner's scoop

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Abstract. The article is devoted to determining the technical and operational productivity and the main parameters of the new screw working body, in collaboration with the laser planner scoop, to achieve optimal parameters of the technological process of leveling the fields of farms. The possibility of up to 30% saving of irrigation water, as well as increasing crop yields, depends on the quality of planning.

1. Introduction

Agricultural lands belong to fertile lands, are considered the main means of national wealth, agricultural production, and ensuring food security of the country. The total area of agricultural land is 20,236.3 thousand hectares, of which arable land is 3,988.5 thousand hectares, perennial plantings-383.1 thousand hectares, deposits -76 thousand hectares, hayfields, and pastures - 11,028, 3 thousand hectares, other lands - 4 760.4 thousand hectares. In recent years, systematic measures have been taken in Uzbekistan to improve land and water relations, optimize agricultural land and apply a simplified procedure for their allocation, introduce modern market mechanisms, innovative and resource-saving technologies for using land and water resources, and produce highly profitable, export-oriented types of products by reducing low-profitable cotton and grain areas [1, 2]. The issues of rational use of water resources and the planning of irrigated lands are almost directly dependent [3, 4, 5]. Due to the large volume of reclamation work, the effective use of irrigated land to obtain high yields of raw cotton and other agricultural products, the quality of the implementation of field planning is of great importance.

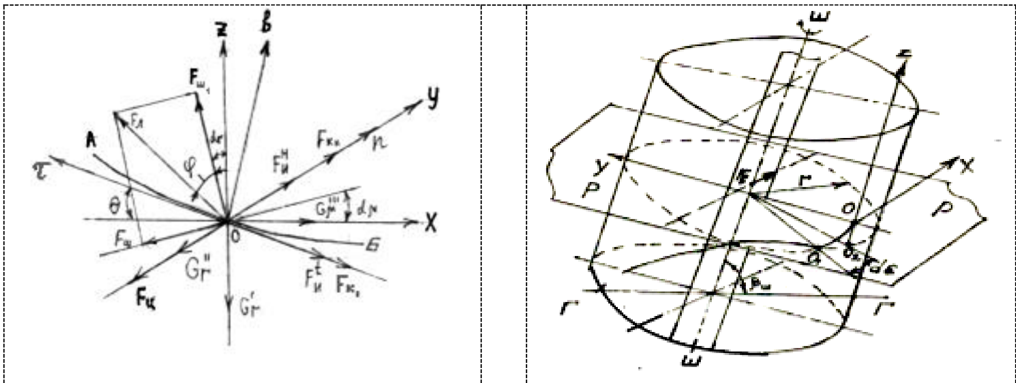
To ensure the high quality of the technological processes, including irrigation in any way, it is necessary to pay special attention to capital planning and the mandatory periodic implementation of field operational planning.

The layout of irrigated land provides the following basic conditions for the cultivation of crops [6, 7, 8, 9]

- the most complete use of the irrigated area;
- uniform soil moisture throughout the irrigated area
- with minimal loss of water and an increase in labor productivity during irrigation,
- complex mechanization of crop cultivation and high labor productivity;
- reducing soil erosion;
- increase the efficiency of the use of high-speed units.

2. Methods

In the method under consideration, it is scientific to substantiate the use of a screw working body on the current layout of irrigated areas, which helps to increase productivity. When using a screw working element at the current and pre-sowing leveling of sowing areas, the traction movement of the soil is reduced by 8 ... 10%, this reserve can be used to increase the speed of translational movement and increase the width of the planner's grip, which helps to increase work productivity [9, 10]. It is known that the magnitude and nature of the change in the angular velocity of a material particle determine the productivity and energy indicators for conveying the material with a screw [11, 12]. Consider the movement of a soil shaft particle with a mass d_m located at point O of an inclined cylindrical screw at a distance r from the screw axis (Figure 1, a and b.) And moving along the trajectory of the absolute AB movement; the axes τ, b, and n are the tangent, binormal, and normal to the path of absolute motion, respectively. The n axis is directed toward the center of curvature and coincides with the y-axis. The Z-axis is parallel to the screw axis, the x and y axes are tangent and normal to the plane of the PP screw, perpendicular touts axis; ГГ horizontal plane [13].



a) b)

Figure 1. To the derivation of the differential equation of motion of a material particle in the auger and the calculation of productivity: a, b are schematic diagram of a screw and forces acting on a soil particle

3. Results and discussion

The following forces act on a soil particle: particle gravity $G_r = gdm$, which can be decomposed into three components, axial $G_r^I = G_r.sin\beta_{sh}$ (along the z-axis), radial $G_r^{II} = G_r.cos\ \beta_{sh}\ cos\varepsilon$ (along the y-axis) and tangent $G_r^{III} = G_r.cos\beta_{sh} \cdot sin\varepsilon$ (along the x-axis); centrifugal force $F = \omega_r{}^2 \cdot \mu \cdot d \cdot m$ (along the y-axis), the friction force of the particle on the blade cover $F_{к_1}$ (along the τ axis), the friction force on the helical surface F_{sh} (at an angle of inclination of the helix to the x-axis); tangential inertia, acting along the tangent to the path of absolute particle motion (axis τ) and directed opposite to the particle's absolute velocity vector $\overline{V}$ (Figure 2, a); normal inertia force directed to the center of curvature of the trajectory (along the n axis); the normal reaction of the adjacent layer F_k (along the n axis) and the helical surface F_1 (at an angle ar to the z-axis) β_1- the angle of inclination of the screw to the horizon; $\mathcal{E}$ is the current angle of rotation of the particle, measured from the projection of the O_2 particle on the PP plane. The resultant F_l of the normal reaction of the helical surface F_{sh} and the friction force against the helical surface deviates from the normal and the helical surface by the angle of friction $\varphi = arctgf$, where f is the coefficient of friction of the soil over the screw metal. If we consider that the loosened soil in front of the planner bucket is clay, then the value of this coefficient is 0.6 ... 0.7 [14].

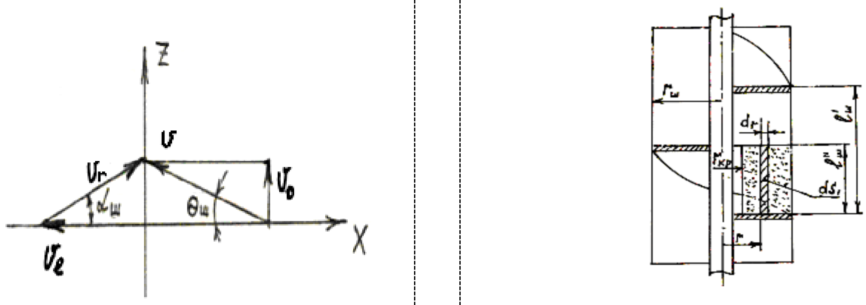


Figure 2. To the derivation of the differential equation of motion of a material particle in the auger and the calculation of productivity: a is speed plan; b is scheme for calculating performance.

The friction force of a particle on a bucket caused by the combined action of forces $F_1 u\ G^{II}_r$ is equal to

$$F_{k_1} = f_r(F_1 + G_r^{II}) = f_r(\omega_r^2 \cdot r + g\cos\beta_1 \cdot \cos\varepsilon)\cdot dm,$$

where f_r and f are the coefficients of friction of the particle on the bucket and the adjacent layer of material, and the helical surface, respectively. Absolute particle velocity

$$\vartheta = \sqrt{\vartheta_t^2 + \vartheta_o^2} = r\sqrt{\omega_r^2 + (\omega - \omega_r)^2 \cdot tg^2 a_r} \qquad (1)$$

Where ϑ_t – is the tangential particle velocity at a radius r from the axis of the screw $\vartheta_t = \omega_r \cdot r$,

ϑ_o is the axial velocity of the particle at a radius r from the axis of the screw $\vartheta_o = (\omega \cdot \omega_r) tga_r$,

ω is screw angular velocity, a_r is the angle of inclination of the helix of the screw on the radius r (Figure 1, a).

The tangent force of inertia is defined as follows:

$$F_u^t = \frac{d\vartheta}{dt}dm = \frac{r[\omega_r - (\omega - \omega_r)tg^2 a_r]}{\sqrt{\omega_r^2 + (\omega - \omega_r)^2 tg^2 a_r}} \cdot \frac{d\omega_r}{dt}dm, \qquad (2)$$

normal inertia force:

$$F_u = \vartheta^2 \cdot r_a^{-1} \cdot dm = r^2[\omega_r^2 + (\omega - \omega_r)^2 \cdot tg^2 a_r]\cdot[r(1 + tg^2\theta)]^{-1} \qquad (3)$$

Where r_a is the radius of curvature of the trajectory at the point in question, $r_a = r(1 + tg^2\theta)$,

θ is the angle of inclination of the helix of the particle path to the X-axis
(Figure 1, a).

$$tg\theta = tga_{ш}(\omega - \omega_r)\omega_r^{-1} \qquad (4)$$

a_{sh} is the helix angle of the screw on the periphery.

According to the d'Alembert principle [15], the equation of the dynamic equilibrium of a material particle in the projections on the axis of the natural trihedron of the trajectory

$$\sum\tau = [F_л \sin(a_r + \theta + \varphi) - G_r^{III}\cos\theta - F_{k_1} - F_u^t - G_r^1\sin\theta]\cdot\cos\varepsilon - (F_ц + G_r^{II} - F_u^{H} - F_{k_{II}})\cdot\sin\varepsilon = O \qquad (5)$$

$$\sum b = \pm F_л \cdot cos(a_r + \theta - \varphi) + G_r^{III}\cdot\sin\theta - G_r^1\cdot\cos\theta = 0, \qquad (6)$$

$$\sum n = (F_ц + G_r^{II} + F_u^{H} - F_{k_{II}})\cdot\cos\varepsilon + [F_л\sin(a_r + \theta + \varphi) - G_r^{III}\cdot\cos\theta - F_{k_1} - F_u^t - G_r^1\sin\theta]\cdot\sin\varepsilon = 0 \qquad (7)$$

Solving these equations together, excluding the force from them $F_л$, after the corresponding transformations of the exception and time by expressing the elementary angle of rotation along the arc O_1, O_2 (Figure 1, b) particles $d\varepsilon = (\omega - \omega_r)dt$, we get:

$$\frac{d\omega_r}{d\varepsilon} = \frac{\pm \frac{\sin([a_r+\varphi)\omega_r + \cos(a_r+\varphi)\cdot tga_r(\omega-\omega_r)}{\cos(a_r+\varphi)\omega_r - \sin(a_r+\varphi)tga_r(\omega-\omega_r)}[g\cdot\sin\beta_ш\cdot\omega_r - g\cdot\cos\beta_ш\sin\varepsilon\cdot tga_r(\omega-\omega_r)] -}{(\omega-\omega_r)r[\omega_r-(\omega-\omega_r)tg^2a_r]} \rightarrow \tag{8}$$

$$\frac{-f_r(\omega_r^2 + g\cdot\cos\beta_ш\cdot\cos\varepsilon)\sqrt{\omega_r^2+(\omega-\omega_r)^2\cdot tg^2a_r} - g\cdot\sin\beta_ш\cdot tga_r(\omega-\omega_r) - g\cdot\cos\beta_ш\sin\varepsilon\cdot\omega_r}{(\omega-\omega_r)r[\omega_r-(\omega-\omega_r)tg^2a_r]}$$

By integrating equation (8.) by the Euler method, we can obtain the dependence curves ω_r from ε for screws with various parameters [15, 16].

In horizontal ($\beta_ш<30^o$) auger in the period of steady motion, the angular velocity of the particle is zero. The angle of rotation of the particle ε, at which the steady motion begins, depends on the initial conditions and can be found from equation (8):

$$\varepsilon = arctg[f_r\sin(a_r+\varphi)\cos^{-1}(a_r+\varphi)] \tag{9}$$

The maximum productivity on loose soil, determined by the throughput between the upper turns of the screw will be:

$$\varPi = \int_{r_{кр}}^{r_ш} \vartheta_r dS \tag{10}$$

where $r_ш$ is the outer radius of the screw, ϑ_r is the speed of soil sliding along the screw surface of the screw (relative speed), dS is the elementary cross-sectional area of the soil located between the upper turns in a plane perpendicular to the relative velocity vector.

The soil in the cross-section of the screw by a plane passing through the axis of the screw occupies an area bounded from below by a straight line perpendicular to the axis of the screw (Figure 2, b). Then in the section, we get a rectangle of length l^{II}, which can be taken equal to the screw pitch $l^{II} = l^{I}_ш$.

The elementary soil cross-sectional area at a distance r from the screw axis will be equal to:

$$dS = dS_1\cos a_r = l^1 dr\cos a_r = 2\pi l^1(\sqrt{4\pi^2r^2+(l^1)^2})^{-1}\cdot rdr, \tag{11}$$

where dS_1 is the elementary soil area in the axial section (Figure 2 b) In horizontal and sloping augers with a tilt angle $\beta_ш \leq 30^o$ angular velocity of a material particle $\omega^{cp}_{r_ш} = 0$. To calculate the capacity (m^3/ h), you can use the following formula:

$$\varPi_T = 450(d-d_b^2)l^1\omega\cdot K_H K_\beta\cdot K_p^{-1} \tag{12}$$

Where d_{sh}, d_b are the respectively, the diameters of the screw and shaft, m; $K_н$ is the screw filling ratio, for our case, we can take equal $K_н=0.2…0.4$; [17, 18]

K_β is the coefficient taking into account the angle of inclination of the screw to the horizontal $K_\beta=1.0…0.8$,

K_p is the soil loosening coefficient, for our case $K_p=1.14… 1.28$ [19, 20].

The main parameters of the screw working body include the length of the transporting part - $l_ш$, cutting parts - $l_ш$, screw diameter - $d_ш$, peripheral speed on the cutting edge $\vartheta_{окр}$,, screw pitch - $l^1_ш$, working speed ϑ_p.

The length of the conveying and cutting parts of the screw is taken constructively, based on the type of screw and the parameters of the medium being processed. For preliminary calculations, it is possible to take the length of the transporting part of the horizontally located screw $l_ш=l_p=(0.7…0.8)B_n$, where B_n is the width of the scoop bucket. The diameter of the screw $d_ш$ with a horizontally located working body for a given productivity $\Pi_т$ can be determined from formula (12) after some transformations,

$$d_ш \geq \sqrt{П_T\ К_р(900\vartheta_{окр}К_аК_нК_\beta)^{-1} + d_в^2}\ , \qquad (13)$$

where ϑ_{okp} - peripheral speed on the cutting edge of the screw, ϑ_{okp} = 1.5 ... 3 m / s; $К_a$ - coefficient taking into account the inclination of the cutting edges of the screw, $К_а = l_ш / d_ш = 0{,}7...1{,}0$.

The step of the horizontal screw is taken equal $l_ш^1 = K_a d_ш$, the value of K_a is taken depending on the inclination of the cutting edge of the screw. For our case, we can take K_a equal to 0.85.

The working speed of the soil moving with the screw should be equal to the speed of filling the bucket of the scheduler with soil. The latter depends on the progressive speed of the planner. For our case, with a certain accuracy, we can take $\vartheta_{гр} = \vartheta_{ков} = \vartheta_n$, where $\vartheta_{гр}$ is the speed of moving the soil with a screw, $\vartheta_{ков}$ is the speed of filling the planner bucket with soil, $\vartheta_п$ is the translational speed of the planner, m/s.

The working speed of the planner's movement can also be determined from the conditions for ensuring a given performance on a cut of soil with a planner bucket. For a horizontal auger, operating speed (ϑ_n) of movement, m / s:

$$\vartheta_П = П_T \cdot l_p^{-1} h_p^{-1}, \quad (14)$$

$П_t$ is the productivity of the planning unit on a cut of soil, m^3/h, l_p is the length of the cutting part of the planner's knife, m, h_p is the thickness of the cut soil layer, m.

4. Conclusions

From the analysis of the above theoretical background for determining the performance of a screw working body, it follows that with an increase in the speed of rotation and diameters of the screw, the productivity of the screw working body increases. At the same time, the screw pitch is also of great importance, with an increase in which the volume of the transported soil increases to the side walls of the planner bucket, which in turn contributes to an even distribution of the soil of the drawing prism along the width of the planner passage. With an increase in the speed of translational movement of the planner, the working capacity of the screw working body increases, that is, the screws move a large amount of soil to the sides relative to each other. As shown by selective experiments with the experimental model of a mini-planner, such an improvement in the work of the screw working element occurs under the influence of the translational speed of up to 2 m/s. Above this speed, the screws begin to become clogged with soil and the technological process of the screw working body is violated.

Reference

[1] Decree of the President of the Republic of Uzbekistan dated June 17, 2019 № UP-5742 *On the effective use of land and water resources in agriculture*

[2] Following documents which are approved by council of Ministers and regional authorities The state Resolution on wisely using water resources and improving ameliorative state of irrigating lands during 2013-2017 years

[3] Akhmedzhanov M A 1991 Planning of irrigated land *Mekhnat* Tashkent

[4] Khikmatov P G 1978 The study of the qualitative and technological indicators of the work of the long-base scheduler in order to substantiate the optimal width and motion speed *Abstract of the PhD* Tashkent

[5] Azizov M 1992 Land planning and productivity og cotton *Agriculture of Uzbekistan* pp 50-51

[6] Sokovikov V K 1984 Influence of unevenness of land surface on qualitative indicators of MTA *Mechanization and electrification of agriculture* **3** pp 50-53

[7] Akhmedjhanov M A 1992 The economic value of the planned land in the cultivation of crops. *Mechanization of cotton growing* **5** pp 10-11

[8] Hasanov I S, Hikmatov P G 2003 Study of the effectiveness of the use of planning machines and the choice of the type of tool for farmers of Bukhara region *Reports of the international scientific-practical conference*
[9] Akhmedjanov M A 1983 Comprehensive research and development of technology and means of mechanization in the operational planning of irrigated land in the cottonseed of the USSR *The dissertation for the degree of Doctor of Technical Sciences* Toshkent
[10] Quchqorov J J, Turaev B M and Murodov M M 2018 Calculations on spherical disk instant center of rotation Science Poland modern scientific challenges and trends collection of scientific works of the international scientific *conference* **8** pp 129-131
[11] Rakhimov N, Muradov R 2012 Manual on laser leveling and soil softening Tashkent pp 23-26
[12] Hikmatov P G 2015 and others Theoretical prerequisites for determining the productivity of the shneck, working with the scheduler bucket Russia *Agrarian science scientific-theoretical and industrial journal* **6**
[13] Khasanov I S 2016 Etermination of the productivity of a screw working body Russia *Agrarian science scienDtific-theoretical and industrial journal* 6
[14] Olimov Kh Kh 2019 Founding technological process and parameters of longitudinal pawl maker device between cotton rows *Dissertation abstract of doctoral of philosophy (PhD) on technical sciences* 2019
[15] Khikmatov P G 2018 Methods for determining the traction resistance of long-base planners *Modern scientific challenges and trends (Collection of scientific works of the international conference* **8**
[16] Khasanov I S, Khikmatov P G and Kuchkarov Zh Zh 2016 Increasing the stability of work of planning units Russia *Modern materials, equipment and technologies Scientific and practical journal* **1(4)** pp 221-225
[17] Govermental documents on construction, reconstruction fixing works in the ameliorative systems and buildings Tashkent – 2015 p 56
[18] Shevnnin Yu A, Burmiysky G G 1990 Ways to improve the efficiency of land-planning machines in construction and agriculture Tashkent p 27
[19] Contemporary scientific and practical conferences on *Modern problems of agriculture and water management* Part **I** Tashkent p 96
[20] Kuchqorov J Musurmanov R 2019 Experience results of softening disc near the grader scoop *International Journal of Advanced Research in Science Engineering and Technology* **10** p 9