PAPER • OPEN ACCESS

Determination of the absolute and relative soil velocity in the bucket of a rotary wire cleaner

To cite this article: T U Usmonov *et al* 2023 *IOP Conf. Ser.: Earth Environ. Sci.* **1206** 012039

Determination of the absolute and relative soil velocity in the bucket of a rotary wire cleaner

T U Usmonov, M S Karimov*, Z Sh Sharipov and N K Usmanov

Tashkent National Research University – «Tashkent Institute of Irrigation and Agricultural Mechanization Engineers (TIAME), 39. Kary-Niyaziy str., Tashkent, Republic of Uzbekistan

* E-mail: Karimovmaksud245@gmail.com

Abstract. Maintaining the reclamation network in working order requires annual restoration work, which consists in cleaning it from sediment and vegetation, as well as performing various types of repair and construction work. The specificity of the maintenance of irrigation systems is that the specific volumes of excavation are insignificant, and the objects themselves are dispersed over a large area. For the timely and high-quality performance of a large amount of repair and maintenance work on reclamation systems, a significant amount of specialized equipment is required. Recently, a large number of experimental models of sewer cleaning machines and mechanisms for cleaning irrigation systems have been created. At present, when creating new cleaning machines, they are supplied with replaceable working equipment, including for cleaning concreted channels and trays. In the future, the range of interchangeable equipment is planned to be expanded. The article deals with the theory of the movement of the soil particle being cut (deposition) over the working body and the ejection velocity of these particles. When unloading from the tray, which affects the power consumption of the rotor tray-cleaning engine.

1. Introduction

An analysis of domestic and foreign ones allows us to conclude that their working bodies are not suitable for cleaning trays from sediments and vegetation of their entire silty section. Therefore, it is necessary to theoretically substantiate the rational type of the working body capable of cleaning the trays in one pass of the machine with effective specific indicators.

The process of cutting the deposited layer by the active working body is significantly affected by the translational working speed of the machine vn, which determines the thickness of the chips t and the feed per revolution of the rotor-thrower Sb. Depending on the rotational speed of the rotor, at a constant translational speed of the pan cleaner and the thickness of the cut chips (cutting section), the energy intensity of the cutting process and the specific productivity of the pan cleaner change.

It is known that the rotor in its design is the most [1, 3, 5] perfect working body with high efficiency and the ability to operate at high speeds.

The rotor-thrower during rotation cuts off the alluvial soil in the tray in separate portions with semi-cylindrical buckets and throws it out from outside the tray. In the process of rotation, the relative and translational speeds of the cut portion of the soil change in direction and magnitude, because of this, the absolute speed of the soil in the bucket in one revolution takes on different directions with respect to the translational speed of the pan cleaner. Depending on the mass of the cut soil and the magnitude of its absolute speed, dynamic loads arise on the elements of the rotor, the energy consumption for ejection of the soil, the angle of its ejection, etc. change [12,13].

2.Materials and methods

Consider the movement of an elementary soil particle M in the rotor bucket relative to the moving axes $0_1x^1y^1z^1$ (fig.1). Let's assume that the system of axes $0_1x^1y^1z^1$ has a relatively fixed frame of reference 0xyz progressive movement. Point speed 0_1 denote by υ_{0_1}.

It is known that during the translational motion of a rigid body, all its points at any given moment have the same speed. Therefore, the speed of any point, invariably associated with the moving axes, is equal to the speed of the point 0_1[2, 6, 7, 11].

Therefore, the portable speed of point M at any given moment is equal to the speed of point 0_1 at the same moment, that is $\vartheta_{01} = \vartheta_n$.

The distance that the point M moves along the axis of rotation during one revolution of the rotor is the ball of the helix S. During helical motion, the angular velocity of the point M is determined by the relation:

$$\phi/t = \omega \tag{1}$$

where $\phi -$ angle of rotation of the material point of the soil in the bucket of the rotor, deg;

t- time of rotation of the material point, s.

Carrying speed M is constant (υ_n = const) and forte the point moves along the generatrix at a distance:

$$mM = \upsilon_n t \tag{2}$$

The equations of motion of a point can be written in the following form

$$X' = rCos(\omega \cdot t)y' = rSin \cdot (\omega \cdot t)Z' = \upsilon_n t \tag{3}$$

Relative velocity expansion formula v_r along the moving axes can be represented in the following form

$$\upsilon_r = \frac{dx^1}{dt} i^1 + \frac{dy^1}{dt} j^1 + \frac{dz^1}{dt} k^1 \tag{4}$$

where: $\frac{dx^1}{dt}; \frac{dy^1}{dt}; \frac{dz^1}{dt} -$ relative velocity projections on the moving axis.

$i^1; j^1; k^1 -$ orths of moving axes.

The absolute speed of the point M relative to the fixed reference frame OXYZ is equal to the vector time derivative of the radius vector R of the point M drawn from the fixed origin O

$$\upsilon_a = \frac{dR}{dt} \tag{5}$$

The radius vector r_1 can be expanded in terms of moving axes according to the following formula

$$r_1 = x'i' + y'j' + z'k' \tag{6}$$

where: $x'y'z'$ - coordinates of the point M in the moving frame of reference.

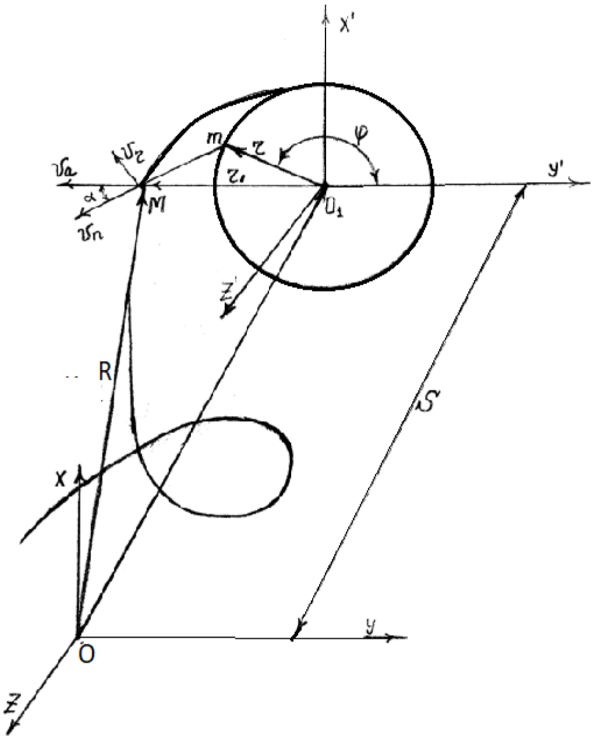

Figure 1. Determination of the absolute speed of the soil in the bucket rotor – thrower Radius - vector R is determined from the expression

$$R = r_{01} + r_1 \quad (7)$$

Then:

$$R = r_{01} + x^{!}i^{!} + y^{!}j^{!} + z^{!}k^{!} \quad (8)$$

3. Results and discussion

Differentiating equality (8) with respect to t and taking into account that during the translational movement of the moving axes [3,8-10], the unit vectors are constant vectors, since their modules and direction do not change, we obtain the following formula:

$$v_a = \frac{dR}{dt} = \frac{dr_{01}}{dt} + \frac{dx^1}{dt}i^1 + \frac{dy^1}{dt}j^1 + \frac{dz^1}{dt}k^1 \quad (9)$$

where:

$$\frac{dr_{01}}{dt} = v_{01} = v_n, \qquad \frac{dx^1}{dt} = -rw\,sin(wt) \quad , \qquad \frac{dy^1}{dt} = rw\,cos(wt) \quad , \frac{dz^1}{dt} = v_n$$

According to the velocity addition theorem, the absolute velocity of the point M is equal to the geometric sum of the translational and relative velocities, then:

$$v_a = v_n - rw\,sin(wt) + rw\,cos(wt) + v_n = 2v_n + rw[cos(wt) - sin(wt)] \quad (10)$$

Expressing the product (wt) in terms of the angle of rotation after some transformations, we obtain the following formula for determining the absolute speed υ_a of the point M.

$$v_a = 2v_n + rw(cos\,\phi - sin\,\phi) = 2v_n - rw\,sin(\phi - 45^0)\sqrt{2} \quad (11)$$

Consider the formula for the relative speed of soil in the bucket of the rotor

$$v_r = v_п - rw\, sin(\phi - 45^0)\sqrt{2} \qquad (12)$$

The value (rω) expresses the peripheral speed of a point belonging to the rotor bucket, located at some distance from the rotor axis in fixed coordinates OXУZ.

Ground movement, in the bucket depending on the angle of rotation φ with circumferential speed $v_{ок}$ combined with carry speed $v_п$ shows a picture of the change in the relative speed of the soil and the process of its movement in the bucket in moving coordinates 01X1У1Z1.

The value of the relative ground velocity v_r depending on the angle of rotation φ counterclockwise when counting from the У1 axis acquires a number of extreme values and is determined by the formula:

$$v_r = v_п + v_{ок}\, sin(\phi - 45^0)\sqrt{2} \qquad (13)$$

where: φ =0…360° - angle of rotation of a material point of the soil in the bucket.

The maximum value of the relative ground velocity is at the angle of rotation φ on the 10°, and the minimum at the angle of rotation φ on the 80° in the first quarter of the circle.

The maximum (minimum) value of the absolute ground movement velocity is determined by formula (11) and its direction from the following relation:

$$v_п / v_a = cos\, \alpha \qquad (14)$$

Substituting in formula (13) the value of the absolute velocity, we obtain the expression

$$cos\, \alpha = v_п / 2v_п - v_{ок}\, sin(\phi - 45^0)\sqrt{2} \qquad (15)$$

Denoting the value Sin(φ - 45^0) at the peripheral speed of the soil through K we obtain the following formula:

$$cos\, \alpha = \frac{0{,}705 v_к}{1{,}41 v_п - v_{ок} К} \qquad (16)$$

where: $v_к$ - portable speed of a material point.

К - the value of the angle of rotation, material point in the bucket.

$v_{ок}$ - circumferential speed of a material point.

4.Conclusions

Thus, from the above, we can bring the following: From the above formulas (10.11) it can be seen that the absolute speed of the rotor depends on the portable and relative speeds of the pan cleaner. Rotation angle options φ and portable speed vк shows a picture of the change in the relative speed of the soil in the bucket of the pan cleaner rotor.

These obtained results are considered to be our assigned tasks and give a complete picture of the provision in the process of cutting and ejecting the alluvial layer of soil from the tray, which increases the useful power of the engine.

The increase in power consumption from the rotor speed is explained by the fact that at a constant translational speed of the pan cleaner, the feed per revolution of the rotor decreases and thinner chips are cut and partly the power is spent on soil dispersion.

In the process of work, cutting and moving of the soil sediments is carried out. Cutting occurs at optimal angles of installation of the cutting elements. Soils are homogeneous of the second category. Cutting conditions are constant at different thicknesses of silting trays. There is no soil sticking to the working surface of the cutting elements.

References

[1] Israfilov N A 1984 Substantiation of optimal parameters and mode of operation of rotary sewer cleaning machines. Questions of agricultural mechanics Edited by acad. M.E. Matsepuro (Minsk, Harvest)
[2] Voronkov I M 1965 Course of theoretical mechanics (M: Science) 596 p
[3] Improvement of construction and reclamation equipment for water economic construction of Uzbekistan 1988 (Collection of scientific works TIIAME, Tashkent) p 48
[4] Scientific and technical report of TIIAME on topic 3.12.1 "Improving the efficiency of mechanization of cleaning from sediments and vegetation of irrigation channels and trays Toshkent 1985
[5] Achkasov G P etc. 1984 Technology and organization of repair of melshrativnyh hydraulic structures (M: Kolos)
[6] Usmonov T U, Karimov M, Li A S, Sharipov Z 2019 *Improvement of tray cleaning technology. Scientific works of the III-international scientific-practical conference "Agrarian science of the XXI century, current research and prospects"* (Ministry of Agriculture of the Russian Federation Federal State Budgetary Educational Institution of Higher Education, Kazan State Agrarian University, Kazan)
[7] Baritarev V A, Zamyshlyaev V F 1984 *Mining machines and complexes* (M. Nedra) 288 p
[8] Lee A, Norov B 2020 *Seiling and cleaning of channels* For taking part in the International ScientificConference “Construction Mexanics, Hudraulics and Water Resources Engineering”(CONMECHYDRO – 2020, Tashkent, Uzbekistan)
[9] Majugin E I, Kazakov A L 2014 *Canal cleaners. Guidelines for performing laboratory work* (Gorki BSHA) 37 p
[10] *Handbook of the designer of road machines* 1973 Ed. Dr. tech. sciences, prof. I.P. Borodacheva (M: "Engineering") 586 p
[11] Sharipov Z Sh, Usmonov T U., Karimov M S, Usmanov N K 2021 Technology and equipment for cleaning sprinkler trays *Bulletin of the agricultural science of Uzbekistan* **1(85)** 149-152
[12] Karimov M S, Lee A S, Usmonov T, Sharipov Z, Utepov B 2022 The working equipment of the sewer cleaning machine. printed. Patent. Useful model. No. FAP 2019 0191. 01/31/2022.6-bet.
[13] Shumakova B B 1990 *Reclamation and water management* Irrigation (Handbook M., Agropromizdat) 415 p