UDC 514.18

PWow PARTICLE SURFACE IN MINERAL FERTILIZERS TUKONAPRYAMNYKA IN THE FORM OF ELLIPTIC CYLINDER

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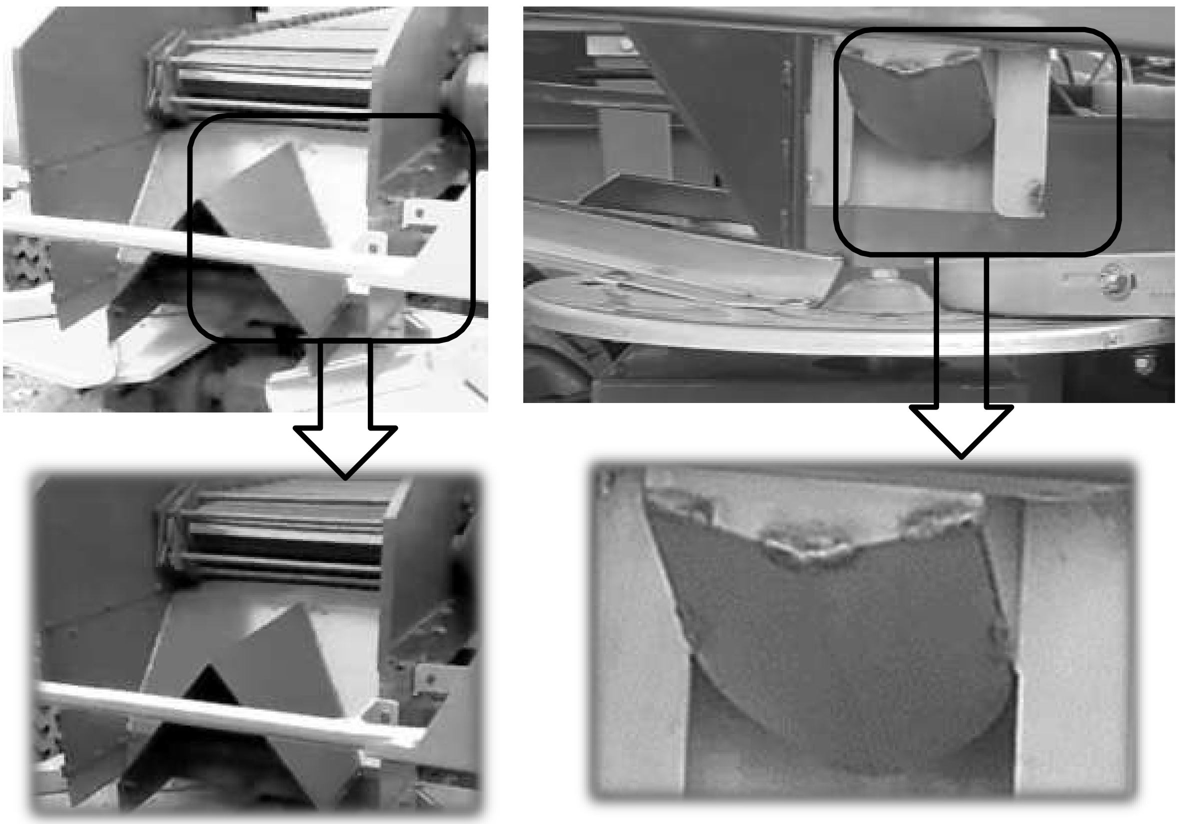
Shows trajectory-kinematic characteristics of motion of particles of mineral fertilizers on a fixed rough inner surface of old elliptical cylinder.

Rouxx particles, rough surface, elliptical cylinder, the system of differential equations, trajectory, speed.

Resolutionska problem. Chaparticle fertilizer hopper capacity of the disk protector pass through a series of guiding devices (Fig. 1). One of them is tukonapryamnyk, the main purpose of which is to supply a certain amount of fertilizer to a location diffuser disk.



and) b)

Ric. 1. View tukonapryamnykiv fertilizers.

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In domestic car bn tukonapryamnyk consists of several inclined plane (Fig. 1 a). In foreign cars for mineral fertilizers used tukonapryamnyky cylindrical shape (Fig. 1b). Understanding the laws of motion of a particle on various rough surfaces will purposefully to calculate structural parameters of certain forms tukonapryamnykiv fertilizers.

Toslidzhennya trajectory-kinematic characteristics of a particle leads to the need to develop a system of differential equations of 2nd order and its approximate solution,
uO is a very time consuming process and without the use of modern symbolic algebra packages make virtually impossible.

AnaLiz recent research. Toslidzhennyu movement of particles Shorestkyh dedicated work surfaces Acad. Vasilenko PM [3]. The theory of centrifugal machines for working fertilization disclosed in labor Acad. Adamchuky V. [1]. The development of software applications in the field of simulation modeling of "rough surface - moving particle" doable among symbolic algebra Maple [2].

Metand dperssurvey findings. Work outand for withassignmenthigher withandmvolnoyi andlhebry Maple [1] computer model of a particle on the rough surface elliptical cylinder and through computational experiments clarify its trajectory-based kinematic properties: 1) the angle directly throwing particles; 2) coefficient α of external friction; 3) the initial velocity V_o; 4) its initial position $[u_o, v_o]$ f at the time of its motion.

Rezultaty research. Write parametric equations onhyloho elliptic cylinder in a Cartesian coordinate system $Oxyz$ in the following form:

$$\boldsymbol{R}(u,v) = \boldsymbol{R}[a\ cos(u)\,,\ b\ sin(u)\,cos(\xi) - v\,sin(\xi),\ b\ sin(u)\,sin(\xi) + v\ cos(\xi)], \quad (1)$$

a, b where - size of the ellipse semiaxes directing $[a\ cos(u), b\ sin(u), 0]$ Oxy toSectionstrath withandtem $Oxyz$ ξ koordynat ; - Ox u, v Kut ongate vertical QiLeandro tovkola aboutB ; - Creevoliniyni Koridynaty surface.

If you throw a piece of the inner surface of old elliptical cylinder, then gravity will move it to a certain trajectory. Projected on the axis of the cover tryhrannyka
$OuvN$ lawin the motion of a particle will have the following form:

$$\begin{cases} Ou := m\,W\,cos(\widehat{\boldsymbol{R}_u, \boldsymbol{w}}) = F_g\ cos(\widehat{\boldsymbol{R}_u, \boldsymbol{G}}) - f\ F_N\,cos(\widehat{\boldsymbol{R}_u, \boldsymbol{\tau}}) \\ Ov := m\,W\,cos(\widehat{\boldsymbol{R}_v, \boldsymbol{w}}) = F_g\ cos(\widehat{\boldsymbol{R}_v, \boldsymbol{G}}) - f\ F_N\,cos(\widehat{\boldsymbol{R}_v, \boldsymbol{\tau}}), \\ ON := 0 = F_g\ cos(\widehat{\boldsymbol{G}, \boldsymbol{N}}) \pm F_C\ cos(\widehat{\boldsymbol{n}, \boldsymbol{N}}) \end{cases} \quad (2)$$

where $g = 9{,}81$ *m / s2* - Constant acceleration of falling bodies;
$\boldsymbol{G} = [0,0,-1]$ - CategoriesapryaIOC withMudand rdzhinnya $F_N = F_g \cos(\widehat{\boldsymbol{N},\boldsymbol{G}})$ F_g F_C $\cos(\widehat{\boldsymbol{N}\boldsymbol{\omega}})$ $F_g = mg$ NowithandSTEM $Oxyz$;
$F_C = m V^2 k$ -normal reaction force; $F_g = mg$ and - The force of gravity and centrifugal force; $\boldsymbol{w}$ - Particle acceleration vector; k -CreeWine path $\boldsymbol{r}$ Chaparticle, *m-1*; V - Particle velocity, *m / c*; $\boldsymbol{N}$ -Normal to the surface $\boldsymbol{R}(u,v)$ the points of the trajectory; $\boldsymbol{r}$, $\boldsymbol{n}$ - The main normal trajectory of a particle on the surface; $\boldsymbol{\tau}$ - toectop dotychtion trajectoriesth $\boldsymbol{r}$; - toectop Darbyinthreehedron $O\boldsymbol{\tau}\boldsymbol{P}\boldsymbol{N}$ $\boldsymbol{P} = \boldsymbol{N} \times \boldsymbol{\tau}$; - Coefficient of external friction. f

If dabout couplemetric pivnyannya - coordinationnatnoyi BTCand thliptychnoho cylinder (1) substitute the expression uv $u = u(t)$ and $v = v(t)$ soughther path in the interior u, v-Koridynatah, we obtain the trajectory Chaparticle $\boldsymbol{r}(t)$ in the system of Cartesian coordinates $Oxyz$ next form:

$$\boldsymbol{r}(t) = \boldsymbol{r}\left[a \cos(u(t)), b \sin(u(t))\cos(\xi) - v(t)\sin(\xi), b \sin(u(t))\sin(\xi) + v(t)\cos(\xi)\right] \tag{3}$$

According to equations (1) and (3) defines all geometry, kinematic components of the expression (2), for example, the rate $V(t)$ Chaparticle and force $F_N(t)$ normal reaction:

$$V(t) = \sqrt{\left((b^2 - a^2)\cos(u(t))^2 + a^2\right)\left(\frac{d}{dt}u(t)\right)^2 + \left(\frac{d}{dt}v(t)\right)^2}, \tag{4}$$

$$F_N(t) \equiv ON = \frac{am\left(b\left(\frac{d}{dt}u(t)\right)^2 - g \sin(u(t))\sin(\xi)\right)}{\sqrt{\left((b^2-a^2)\cos(u(t))^2 + a^2\right)\left(\frac{d}{dt}u(t)\right)^2 + \left(\frac{d}{dt}v(t)\right)^2}}. \tag{5}$$

Developno software symbolic algebra system Maple allows the entire sequence rather cumbersome analytical calculations automatically make. We obtain the following system of differential equations law of motion of a particle on rough inner surface of old elliptical cylinder:

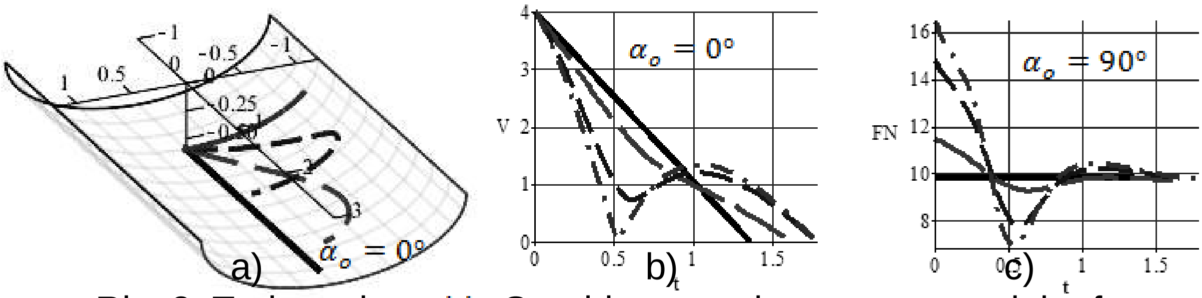
$$\begin{cases} Ou := -\dfrac{m\left(\left((a^2-b^2)\cos(u(t))^2 - a^2\right)\dfrac{d^2}{dt^2}u(t) - \cos(u(t))\sin(u(t))\left(\dfrac{d}{dt}u(t)\right)^2(a^2-b^2)\right)}{\sqrt{(b^2-a^2)\cos(u(t))^2 + a^2}} = \\ \quad -\dfrac{mg\ \sin(\xi)\cos(u(t))\ b}{V(t)\sqrt{(b^2-a^2)\cos(u(t))^2 + a^2}} + \dfrac{fm\dfrac{d}{dt}u(t)\left(-b\left(\dfrac{d}{dt}u(t)\right)^2 + g \sin(u(t))\sin(\xi)\right)}{V(t)\sqrt{V(t)\left(\dfrac{d}{dt}u(t)\right)^2 + \left(\dfrac{d}{dt}v(t)\right)^2}} \\ Ov := m\dfrac{d^2}{dt^2}v(t) = -mg\cos(\xi) - \dfrac{f\ am\left(\left(\dfrac{d}{dt}u(t)\right)^2 b - \sin(u(t))\sin(\xi)\ g\right)\dfrac{d}{dt}v(t)}{V(t)\sqrt{V(t)\left(\dfrac{d}{dt}u(t)\right)^2 + \left(\dfrac{d}{dt}v(t)\right)^2}} \end{cases} \tag{6}$$

FirstWe find conditions for the desired relationships and $u(t)$ $v(t)$ from aboutsystem of state (6) differential equations are:

$$Oi := \frac{d}{dt}u(t_o) = \frac{V_o \sin(\alpha_0)}{\sqrt{(b^2-a^2)\cos(u(t))^2+a^2}}, u(t_o) = u_o, \frac{d}{dt}v(t_o) = V_o \cos(\alpha_0), v(t_o) = v_o. \qquad (7)$$

Roseknit system of differential equations (6-7) can only approximate, for example, by the Runge-Kutta method [2]. Substituting the dependence $u(t)$ and $v(t)$ in discrete form of the equations (3) - (5) allows unaochnyty trajectory of a particle on the surface $r(t)$ of an elliptical cylinder, its speed and power $F_N(t)$ normal reaction $V(t)$.

First, conduct a test experiment - explore the motion of a particle on the rough surface of the horizontal elliptical cylinder (). Fig. 2 built trajectory $r(t)$, $\xi = 90°$ Graphics speed and normal reaction force on the particle surface, depending $V(t)$ on the angle of throwing $F_N(t)$ the following initial conditions: shape parameters, initial velocity $\alpha_o = 0°, 30°, 60°, 90°$, $V_o = 4$ м/с and the coefficient of external friction $f = 0.3$. According $a = 1.2, b = 0.6$ to the schedule (Fig. 2b) speed $V(t)$ WMSto say that all particles over different time t soupRevisions occur. And, stop and fastest particle, which abandoned along the straight generatrix of the cylinder. In stopping particles of normal reaction $F_N(t)$ close to the value mg (Fig. 2, c).



Ric. 2. Trajectories $r(t)$, Graphics speeds $V(t)$ tand the forces $F_N(t)$ depending on the kiprovision α_o Chaparticle horizontal QiLeandro.

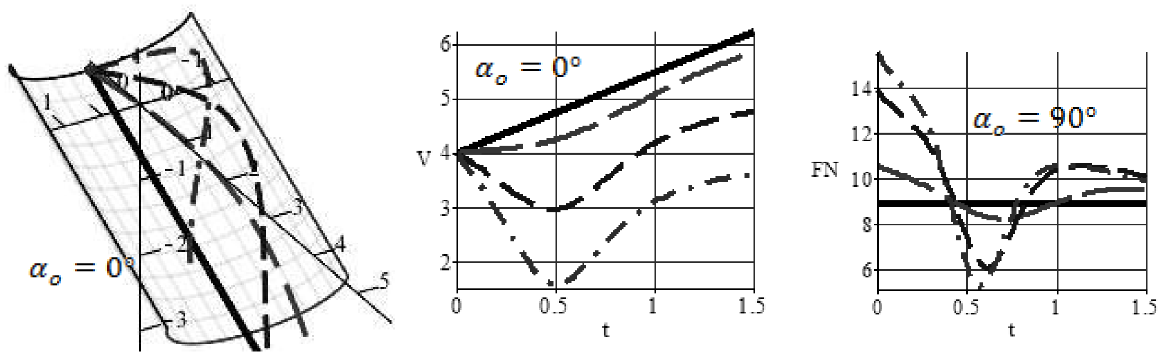
In accordance with the requirements agrotechnological fertilization, terrain slope field must have no more than 8^o[1]. Therefore, the angle ξ pryamoliniynyh generating elliptical cylinder to the horizontal plane must be greater than the value:

$$\xi = 90^0 + atan(f) + 8^0. \qquad (8)$$

Dla meanstion coefficientsiye f fromvnishnoh tertl Chapartic mineral fertilizertoSectionabout Shorestkiy ReturningTheir, naprykorder, $f = 0.3$, will have $atan(f) \approx 17^0$ ξ . Let the angle Categoriesahylelliptical

QiLeandro is. Fig. 3, $\xi = 11.5°$ built trajectory $\boldsymbol{r}(t)$,graphics speed and normal reaction force $F_N(t)$ $V(t)$ Chaparticle depending on the angle of throwing. For graphs speeds $V(t)$ α_o You can see that all the particles never stop on the surface of an elliptical cylinder. The particle thrown perpendicularly to the direction of inclination of the straight cylinder generators, first sharply reduces the rate, but then it gets. Thus, the magnitude of the normal reaction decreases, but then close to a certain value. We see that the particle at the weekend $F_N(t)$ ≈ 8.9 under no detaches from the surface, because along the trajectory of the normal value of the reaction $F_N(t) > 0$. Speed $V(t)$ Keanutoyi particles along the slope increases directly proportional elliptical cylinder. Built trajectory $\boldsymbol{r}(t)$ showThat over time all the particles are closer to the straight path, which coincides with the lowest straight generatrix elliptical cylinder.

On the motion of particles significantly affect its initial position u_o, v_o on the surface, the initial velocity and coefficient of friction V_o f. Fig. 3 and constructed trajectories and velocities of particles schedules $\boldsymbol{r}(t)$ depending original position $V(t)$
$u_o = \frac{\pi}{2}, \frac{2\pi}{3}, \frac{5\pi}{6}, \pi$. We see that all the particles thrown from various places will be collected in a certain area, but their speed will be different.

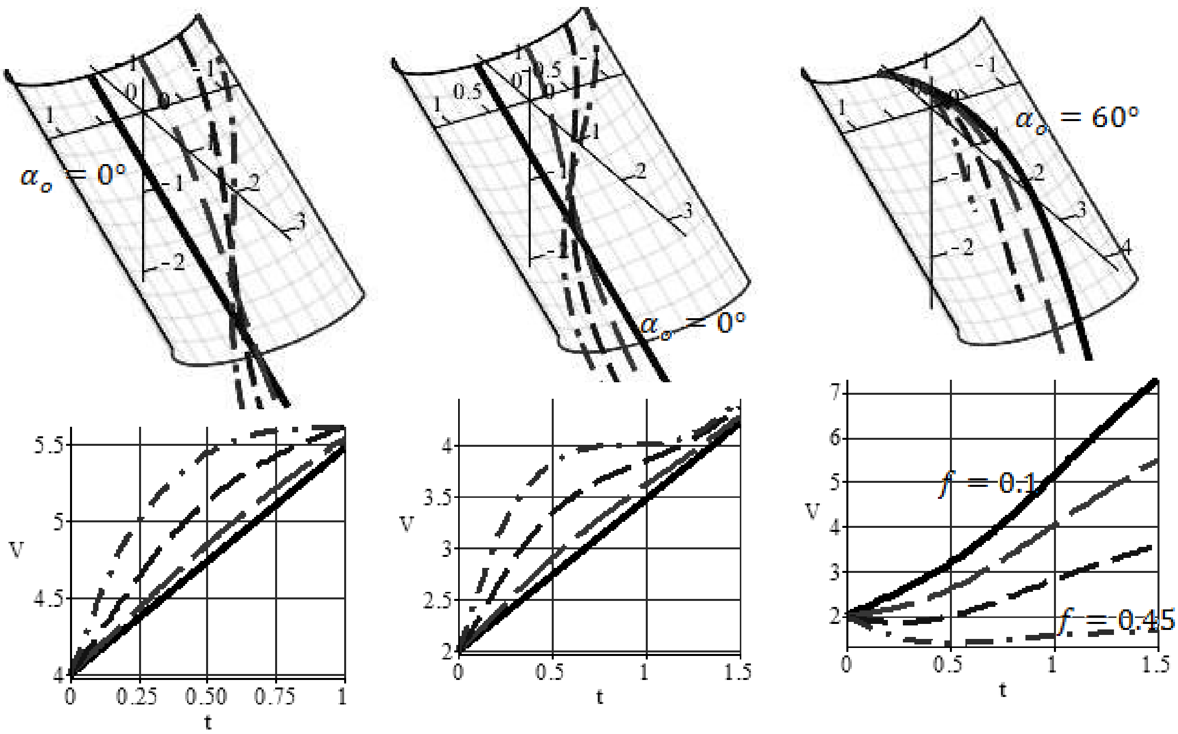


a) b) c)

Ric. 3. $\boldsymbol{r}(t)$, grafics wvydkostey $V(t)$ tand normal reaction $F_N(t)$ depending throwing angle α_o Chaparticle onhylomu cylinder.

If you reduce the magnitude of the initial velocity of the particle $V_o = 4\text{м/с}$ to value $V_o = 2\ \text{м/с}$, The nature of its movement will change proportionally (Fig. 4, B).

The increase in the coefficient of friction f Chaparticle leads to slower it moves over the surface and will soon approach the lowest straight generatrix elliptical cylinder (Fig. 4, B).



a) b) c)

Ric. 4. Trajectories $\boldsymbol{r}(t)$ tand velocity graphs $V(t)$ Chaparticle UMOyou: and)$f = 0.3,\quad V_o = 4\text{м/с}$; to) $f = 0.3,\quad V_o = 2\text{м/с}$; c) $f = 0.01, 0.15, 0.3, 0.45,\ \alpha_o = 60°$.

Conclusion. LnDene study of a particle in the rough inner surface of an elliptical cylinder allows you to set a rather complex relationship between initial conditions throwing particles in the cylinder and its trajectory-kinematic characteristics. In particular, thrown particles from different places on the elliptic cylinder will pass through a certain area on the surface at different speeds and direction.

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Andssledovano Trajectory-kynematycheskye motion characteristics chastychky myneralnыh fertilized by rough inner surface Cyrillic elliptical cylinder.

Movement hastiribbon, sherohocotton onverhnost, elliptic cylinder, traektoryya, speed.

It is investigated trajection-kinematic characteristics of movement of part of mineral fertilizers on rough internal surface of inclined elliptic cylinder.

Movement of particles, surface roughness, elliptic cylinder, trajectory, speed.

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AnalogFrom a mathematical model of the dynamics lifting crane span

VS Loveykin, PhD, VA Holdun, MA

The paper built a dynamic model of lifting mechanism, which is represented as a lumped masses connected by elastic bonds. Based on the dynamic model is the mathematical modeling of the dynamics Lift, performed span crane. The mathematical model is multi-layered, in which each phase is described by differential equations. Also recorded initial and final conditions of individual mass movement. The analysis of the mathematical model, which showed that the phase tension rope and lifting does not allow for pre-specified end traffic conditions reduced weight and axle load.

Pidyom cargo, mathematical modeling, differential equations, Cauchy problem.

Resolutionska problem. PEid runtime navantazhuvalno- handling vehicle are often used cranes. They can increase the efficiency of traffic flow in the enterprise.

Printeraction and cargo and vehicle suspension last occurring heavy loads. They can break elements of the vehicle. In addition, elements of the crane (cargo rope bridge crane, hoist transfer of cargo) is also exposed to dynamic loads. Therefore it is necessary to establish the cause of dynamic loads in a vehicle and crane in order to reduce their effect. Construction and analysis of a mathematical model of the system "lifting mechanism - load - vehicle "allows

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