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RELATIVE MOTION OF THE CORPUSCLE ALONG THE RECTILINEAR VANE ON THE CENTRIFUGAL MEANS

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The law of relative movement of a particle along a rectilinear vane on the centripetal device is discovered. The problem is solved by means of use of two co-ordinate systems - mobile and motionless. It is made parametric equations of an absolute mechanical trajectory of a corpuscle. The solution in a final form is gained.

Keywords: acceleration vector, applied force, trajectory absolute, differential equation, the relative motion.

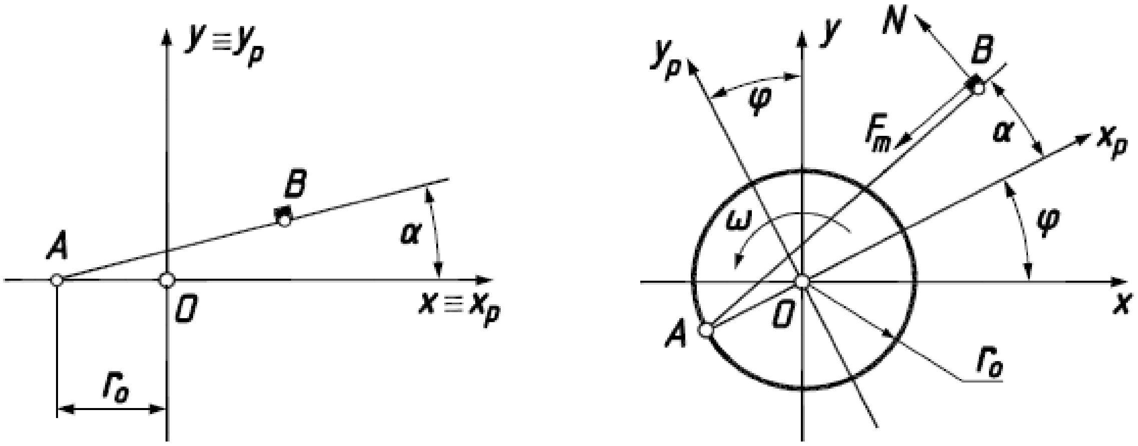
Formulation of the problem. Investigation of the material particles from the horizontal drive straight blades attached orthogonally in its rotation around the vertical axis is the theoretical basis for the design of centrifugal devices for spreading fertilizer. The movement of particles in such devices is complex: it consists of a portable particle motion during rotation of the disk and the relative motion along its blade. Consequently, the complicated task of finding the particle kinematic parameters of this motion.

Analysis of recent research and publications. The movement of particles along a straight horizontal blades rotating disk around a vertical axis sufficiently studied in the works [1-3]. The theory of the movement based on the fact that the movement point studied simultaneously with respect to two coordinate systems. One (main) taken as fixed, and the other performs relative to a stationary relative motion given by law. In turn, in the moving frame made relative motion of the particle. The sum of these movements (relative and portable) is the absolute motion of a particle in relation to the basic coordinate system. In work [4] by moving coordinate system taken cover Frenet-Serret formulas trajectory portable motion.

Formulation of the article purposes. Find law relative movement of particles along a rectilinear blade the example of horizontal centrifugal machine drive.

Main part. Take two flat coordinates that match the initial moment: Oxy fixed and mobile Ohrur. We assume that the mobile system is fixed straight vertical blade that crosses the axis OCR at point A and tilted it at an angle α (Fig. 1 a). By turning the moving system at an angle φ around a common origin shovel will take a new position, with its point A describes an arc of a circle of radius r0 (Fig. 1b). If you set a constant angular velocity ω rotation moving system with a spatula, then at time t, it returns to the angle φ: φ = ωt. During the same period in particle by centrifugal force moves along the blade from its initial position (fig. 1 a) new for some distance u (fig. 1b). Dependence moving particles from the time u = u (t) in relative motion is unknown function that we seek. The provisions of particles moving frame written in projections on its axis through angle α:

$$x_p = u\cos\alpha - r_0; \qquad y_p = u\sin\alpha. \tag{1}$$



a б

Fig. 1. Fixed *Oxy* and mobile Ox_py_p coordinates with fixed straight scoop AB in the moving:

a) both systems coincide at the beginning of the movement;

b) moving relative to the fixed system is turned at an angle $\varphi=\omega t$

During t mobile system with paddle back towards fixed at an angle φ = ωt. The known formulas turn can be written:

$$\begin{aligned} x &= (u\cos\alpha - r_0)\cos\omega t - u\sin\alpha\sin\omega t; \\ y &= (u\cos\alpha - r_0)\sin\omega t + u\sin\alpha\cos\omega t. \end{aligned} \tag{2}$$

Given that the displacement of particles along the blades u = u (t) is a function of time t, parametric equation (2) describe the absolute trajectory of a particle in a fixed coordinate system.

Projections absolute speed and absolute acceleration of particles on the axis fixed coordinate system find consistent differentiation equations (2) at time t. After differentiation (2) and grouping members get the absolute velocity of projection:

$$\begin{aligned} x' &= u'\cos(\alpha + \omega t) - u\omega\sin(\alpha + \omega t) + r_0\omega\sin\omega t; \\ y' &= u'\sin(\alpha + \omega t) + u\omega\cos(\alpha + \omega t) - r_0\omega\cos\omega t. \end{aligned} \tag{3}$$

After differentiating expressions (3) and simplifications obtain absolute acceleration vector projection:

$$\begin{aligned} x'' &= u''\cos(\alpha+\omega t)+ \\ &\quad +\omega\left[r_0\omega\cos\omega t - u\omega\cos(\alpha+\omega t) - 2u'\sin(\alpha+\omega t)\right]; \\ y'' &= u''\sin(\alpha+\omega t)+ \\ &\quad +\omega\left[r_0\omega\sin\omega t - u\omega\sin(\alpha+\omega t) + 2u'\cos(\alpha+\omega t)\right]. \end{aligned} \tag{4}$$

After differentiating expressions (3) and simplifications obtain absolute acceleration vector projection::

$$mx'' = F_X; \qquad my'' = F_Y; \qquad mz'' = F_Z, \tag{5}$$

where *m* – particle mass;

x'', y'', z'' - absolute acceleration projection vector (4);

F_X, F_Y, F_Z - projection resultant forces applied to the particles on the axis fixed coordinate system.

Along the axis Oz is no movement, so z'= 0, and is appended by weight of the particles mg, where g = 9,81 m / s2, and the reaction Nz horizontal disk that Fz = Nz-mg. So, from the last equation (5) we have: Nz = mg. In horizontal disc attached to particles at point B is the friction force FT directed in the opposite direction along the blade slipping particles (Fig. 1b) and the reaction force N with side blades directed perpendicular to it. Friction FT includes two components: the horizontal friction disk fmg, where f - coefficient of friction of the particles on the disk and fN - friction on the blade. This meant that the material of the disc and blades identical, ie f factor for them is common. Thus, friction is written: FT = f (mg + N). Now we can write projections attached to the particle forces in the axis coordinate system moving through the angle α (Fig. 1b):

$$\begin{aligned} F_{Xp} &= -f(mg+N)\cos\alpha - N\sin\alpha; \\ F_{Yp} &= -f(mg+N)\sin\alpha + N\cos\alpha\ . \end{aligned} \tag{6}$$

As we make differential equations projected on the axis fixed coordinate system, the projection of power (6) also need to turn at an angle φ = ωt with floating system:

$$\begin{aligned} F_X &= -\left[f(mg+N)\cos\alpha + N\sin\alpha\right]\cos\omega t + \\ &\qquad +\left[f(mg+N)\cos\alpha - N\sin\alpha\right]\sin\omega t; \\ F_Y &= -\left[f(mg+N)\cos\alpha + N\sin\alpha\right]\sin\omega t - \\ &\qquad -\left[f(mg+N)\cos\alpha - N\sin\alpha\right]\cos\omega t. \end{aligned} \tag{7}$$

Substituting expressions of acceleration (4) and expression of applied forces (7) in the first two equations (5) and obtain a system of two differential equations with two unknown dependencies u = u (t) and R = R (t). Us solve its relatively u'and N and obtain:

$$\begin{aligned} u'' &= u\omega^2 - f(2u'\omega + g) + r_0\omega^2(f\sin\alpha - \cos\alpha); \\ N &= m\omega(2u' - r_0\omega\sin\alpha)\ . \end{aligned} \tag{8}$$

Analyzing (8), we see that the first equation is independent. It can be solved and get the dependence u = u (t). Below is a simplified solution with α = 0, ie radial blades installed:

$$u = \frac{fg}{\omega^2} + r_0 + c_1 e^{\left(-f-\sqrt{1+f^2}\right)\omega t} + c_2 e^{\left(-f+\sqrt{1+f^2}\right)\omega t}, \qquad (9)$$

where c_1, c_2 – continuous integration.

Differentiation dependence (9) give expression sliding speed particles along a rectilinear blade, and his substitution in the second equation (8) gives the pressure dependence of N.

Equation (9) coincides exactly with the same equation in the work [2] (equation (7.1.8) (7.1.9), p. 366), although they received at very different approaches. In work [2] determined the direction of the Coriolis acceleration rule Zhukovsky, which we are also present in projections on the axes.

Висновки. One of the ways for solving problems on dynamics of particles in a complex movement is absolute parametric equations drafting its trajectory, in which the unknown function adopted a law relative movement. Consistent differentiation equations trajectory over time are speed and acceleration. Next problem is solved on the basis of Newton's second law.

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