GALAXY INTERNATIONAL INTERDISCIPLINARY RESEARCH JOURNAL (GIIRJ)
ISSN (E): 2347-6915
Vol. 13, Issue 1 January (2025)

DETERMINATION OF THE ANALYTICAL DEPENDENCE OF THE SORTING PROCESS OF ORGANIC COMPONENTS OF MUNICIPAL SOLID WASTE ON A SCORING MACHINE EQUIPPED WITH A ROTATING ROTOR

Khankelov T. K.
Tashkent State Transport University

ABSTRACT

Based on the theorem of conservation of momentum of the system, a method has been developed for calculating the speed of waste components from impact with the blades of a sorting device. The developed methodology made it possible to calculate the main parameters, the value of the rebound lengths of the waste components, depending on their properties.

Keyswords: Components, rotor, machine, energy, material, calculating, moment, inertia, elastic components, trajectory.

INTRODUCTION

Numerous scientific studies are being conducted around the world to create crushing and screening machines that meet the requirements of manufacturability, controllability of parameters, high productivity, as well as low energy and material consumption [1,2].

In this direction, the creation of highly efficient crushing and sorting machines based on taking into account the morphological and fractional compositions and morphological composition depending on the size of fractions of solid waste and the critical value of the rotor speed of the crushing machine, as well as physical modeling of the crushing and sorting processes of solid waste is of great importance.

Consequently, the development of scientifically based methods for calculating the main design and technological parameters of impact crushing and screening machines is a priority area of theoretical and applied research[3,4,5].

Let us consider the process of collision of the blade of a rapidly rotating rotor of a sorting device with the components of solid waste.

Let us divide the process of sorting the components of solid waste into two stages: the first stage is the collision of the waste components with a rapidly rotating rotor blade; the second stage is the free flight of solid waste components.

Figure 1 shows a calculation scheme for determining the speed of departure of waste components.

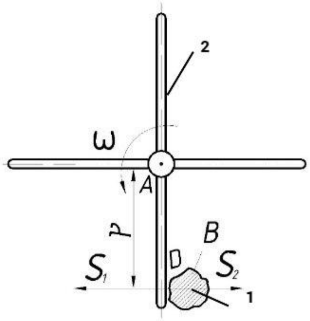

Fig.1. Calculation scheme for determining the speed of waste components at the end of the impact: 1 - components of solid household waste; 2 - rotor.

The rapidly rotating rotor blade at the moment the impact on the solid waste begins has a speed of ω. It is necessary to determine the speed of the solid waste components at the end of the impact. Masses M and m of the rotor blade and the solid waste component, moment of inertia J_A of the rotor blade relative to axis A, coefficient of recovery k.
Let us denote the shock pulses acting on the rotor blade and on the components of the solid waste upon impact through S_1 and S_2. Then for the rotor blade and the solid waste component, taking into account that $S_1 = S_2 = S$, and $\vartheta_B = 0$, we obtain

$$J_A(\Omega - \omega) = -Sr, \quad mu_B = S, \qquad (1)$$

where J_A is the moment of inertia of the rotor blade relative to the axis passing through the center of gravity of the rotor, $kg \cdot m^2$; Ω-post-impact angular velocity of the rotor blade, 1/s ; ω - preimpact value of the angular velocity of the rotor blade, 1/s; S-shock impulse acting on the rotor blade and on the components of solid waste, $kg \cdot m/s$; r - radius of the rotor blade, m ; m -mass of solid waste components, kg ; u_B is the postimpact velocity of solid waste components, m/s.

The moment Sr has a minus sign, since the moment is directed opposite to the direction of rotation of the rotor. In addition, since for point D of the rotor blade
where ϑ_D is the speed of point D at the beginning of the impact, m/s; $u_D -$ is the speed of point D at the end of the impact, $\frac{m}{s}$; k-coefficient of restoration for a direct impact of two bodies gives

$$u_D - u_B = -k(\vartheta_D - \vartheta_B) \text{ или } \Omega r - u_B = -k\omega r, \qquad (2)$$

Substituting here Ω and S from equations (1), we find the speed of the components of the solid waste at the end of the impact

$$u_B = \frac{J_A r(1+k)}{J_A + mr^2}\omega, \qquad (3)$$

To determine the main parameters of the sorting device, in particular the overall dimensions of the hopper, it is necessary to know the flight range of the elastic components of the waste, as well as the maximum lifting height of the waste components. For this purpose, we will draw up a calculation scheme for determining the flight range of the elastic components of waste.

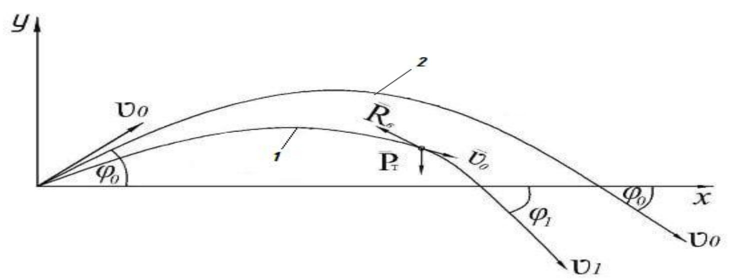

Fig. 2. Calculation scheme for determining the rebound length of solid waste components: 1-flight trajectory of waste components taking into account air resistance; 2-flight trajectory of waste components in airless space.

Let us consider the elastic components of solid waste as material points. We assume that the force of air resistance is proportional to the square of the speed. The components fly off from the end of the sorting device chute along a flat trajectory. A flat trajectory is a gentle curve that forms small (no more than 15 degrees) angles with the horizontal [6].
This is due to the fact that with a flat trajectory, the lifting height of the waste components is insignificant. In addition, the flight range will also not be maximum, this in turn will have a positive effect on the dimensions of the sorting machine.
The differential equation of motion of elastic components in vector form will have a principal normal:

$$m\frac{d\vartheta}{dt} = -mk\vartheta^2 - mg\sin\varphi, \tag{4}$$

$$m\frac{\vartheta^2}{\rho} = mg\cos\varphi, \tag{5}$$

where $\varphi -$ is the angle formed by the tangent with the horizontal axis x, ρ is the radius of curvature of the trajectory. In this case, the infinitesimal angle $d\varphi$ is equal to the angle between the tangents at two close points of the curve (adjacency angle).

Then

$$\frac{1}{\rho} = -\frac{d\varphi}{d\sigma} = -\frac{1}{\vartheta}\frac{d\varphi}{dt}, \tag{6}$$

where $\vartheta = \frac{d\sigma}{dt} -$ speed of elastic components of waste, m/s; $\sigma -$ arc coordinate of the flat trajectory. The minus sign is taken because the angle φ decreases as the arc coordinate σ increases.

Equations (4) and (5) will take the form

$$\frac{d\vartheta}{dt} = -k\vartheta^2 - g\sin\varphi, \tag{7}$$

$$\frac{d\varphi}{dt} = -\frac{g\cos\varphi}{\vartheta}, \tag{8}$$

Eliminating dt from these equations, we obtain

$$\frac{d\vartheta}{d\varphi} = \frac{k\vartheta^3}{g\cos\varphi} + \vartheta tg\varphi. \qquad \frac{d(\vartheta\cos\varphi)}{d\varphi} = \frac{k\vartheta^3}{g}.$$

Dividing both sides of this equation $\cos^3\varphi$ by and separating the variables, we find

$$\frac{d(\vartheta\cos\varphi)}{(\vartheta\cos\varphi)^3} = \frac{k}{g}\frac{d\varphi}{\cos^3\varphi}, \tag{9}$$

Equation (9) is accurate for any trajectories under the quadratic law of air resistance.
For a flat trajectory, when $\cos\varphi$ is small (at an angle no more than , 15^0 $co\varphi$ varies from 0.996 to 1), equation (9) can be represented as

$$\frac{d(\vartheta\cos\varphi)}{(\vartheta\cos\varphi)^3} = \frac{k}{g\cos\varphi_0}\frac{d\varphi}{\cos^2\varphi}, \quad (10)$$

or

$$\frac{d\varphi}{\cos^2\varphi} = \frac{g\cos\varphi_0}{k}\frac{d(\vartheta\cos\varphi)}{(\vartheta\cos\varphi)^3}, \quad (11)$$

Next we find

$$dx = \vartheta_x dt = \vartheta\cos\varphi dt.$$

Substituting the *dt* value from (6) into this equation

$$dt = -\frac{\vartheta}{g\cos\varphi}d\varphi, \qquad \text{we get} \quad dx = -\frac{\vartheta^2}{g}d\varphi$$

We introduce the value $d\varphi$ from (7) into this equation. Then

$$dx = -\frac{\vartheta^2}{g}\frac{g\cos\varphi_0}{k}\frac{d(\vartheta\cos\varphi)}{\vartheta^3\cos\varphi} = -\frac{\cos\varphi_0}{k}\frac{d(\vartheta\cos\varphi)}{\vartheta\cos\varphi}, \quad (12)$$

Integrating (12), we find

$$x = \frac{\cos\varphi_0}{k}\ln\left(\frac{\vartheta_0\cos\varphi_0}{\vartheta\cos\varphi}\right),$$

where

$$\vartheta\cos\varphi = \vartheta_0\cos\varphi_0 \cdot e^{-\lambda}, \quad (13)$$

где $\lambda = \frac{kx}{\cos\varphi_0}$

Let's enter the found value of $\vartheta\cos\varphi$ into equation (9)

$$\frac{1}{\vartheta_0^2\cos^2\varphi_0}\frac{d(e^{-\lambda})}{e^{-3\lambda}} = \frac{k}{g\cos\varphi_0}\frac{d\varphi}{\cos^2\varphi}$$

Integrating this differential equation, we get

$$tg\varphi = tg\varphi_0 - \frac{g}{2k\vartheta_0^2\cos\varphi_0}\left(e^{2\lambda} - 1\right), \quad (14)$$

But, $tg\varphi = \frac{dy}{dx}$, introducing this tangent value into (14), separating the variables and integrating, we find

$$y = xtg\varphi_0 - \frac{g}{4k^2\vartheta_0^2}(e^{2\lambda} - 2\lambda - 1).$$

Expanding $e^{2\lambda}$ into a series in powers of λ we get

$$y = xtg\varphi_0 - \frac{gx^2}{2\vartheta_0^2\cos^2\varphi_0} - \frac{gkx^3}{3\vartheta_0^2\cos^2\varphi_0} - \cdots \quad (15)$$

The equation of the trajectory of the elastic components of the waste without taking into account the forces of air resistance will have the form

$$y = xtg\varphi_0 - \frac{gx^2}{2\vartheta_0^2\cos^2\varphi_0}.$$

Comparing this equation with (15), we see that the third term in (15) is a correction that determines the effect of air resistance on the trajectory of solid waste. The trajectory, taking into account air resistance, is located below the trajectory of solid waste in an airless space.

In order to find the rebound length of the elastic components of the waste, taking into account air resistance, it is necessary to substitute into equation (15)

$$y = 0$$

$$x_1 = 0,\ 2gkx^2 + 3gx - 3\vartheta_0^2 \sin 2\varphi_0 = 0,$$

$$x_2 = \frac{\sqrt{9g^2 + 24gk\vartheta_0^2 \sin 2\varphi_0} - 3g}{4gk}, \qquad x_3 < 0.$$

If we replace x_2 with d, we obtain a formula for determining the rebound length of the elastic components of solid waste along the OX axis.

$$d = \frac{\sqrt{9g^2 + 24gk\vartheta_0^2 \sin 2\varphi_0} - 3g}{4gk}, \qquad (16)$$

The developed program for calculating the rebound lengths of MSW components allows, depending on the properties of the waste, to calculate the rebound length of the waste components, which in turn will allow calculating the main parameters of the sorting device. In addition, this provision will allow the arrangement of the sorting device in the system of complex MSW sorting equipment.

CONCLUSIONS

1. The relevance and demand for research conducted to create and improve the efficiency of operation of devices for sorting solid municipal waste is substantiated, and an analogue of machines is selected to substantiate the main parameters.
2. The developed method for calculating the main parameters of a device for sorting solid municipal waste will allow us to justify the rational values of the main parameters of the device.
3. As a result of the conducted research, the optimal arrangement of sorting equipment in the integrated waste processing system was substantiated.

REFERENCES

1.Александровская З.И. «Санитарная очистка городов». М.: Стройиздат. 2001.-432с.
2.Веников В.А. Теория подобия и моделирование. М.: Высшая школа.2014.-440с.
3.Варданян.Г.С. Прикладная механика. Применеие методов теории подобия и анализа размерностей к моделированию задач механики деформируемого твердого тела.М.: Инфра-М.2018.-174с.
4.Пановко Я.Г. Введение в теорию механических колебаний.-Л.: 2010.-272 с.
5.Подобие и моделирование в системе проектирования дорожно-строительных машин: учеб. пособие / В.И. Баловнев. – М.: МАДИ, 2014.