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THE INFLUENCE OF TECHNOLOGICAL PARAMETERS OF THE ELEVATOR ON COTTON SEED DAMAGE

TURDIEV BAKHTIYOR

Assistant, Termez State University of Engineering and Agrotechnologies, Termez, Uzbekistan

ROSULOV RUZIMURAT

Professor, Tashkent Institute of Textile and Light Industry, Tashkent, Uzbekistan

Abstract: The article theoretically analyzes the forces affecting the seed flow during transportation of cotton seeds by bucket elevators. It also analyzes the influence of technological parameters on seed damage. The theoretical studies show that the impact of seeds ejected from the elevator buckets on the proposed belt conveyors has led to a decrease in seed damage. It has also been established that seed damage depends on the roughness of the striking surface and the speed of the belt, and rational parameters for the studied elevator are recommended.

Keywords: elevator, bucket, conveyor, drive, seeds, damage, belt drive, trajectory, speed, rigidity.

Introduction. It is known that in the internal and interdepartmental flow system for transporting cotton and cotton products, continuous mechanical and air transport means are widely used.

In the cotton cleaning industry, as well as in other sectors, various types of equipment are used for transporting finished products and semi-finished goods produced in the industry, as well as fruits and vegetables grown in agriculture. For example, conveyors and elevators are used for transporting agricultural products, grain, potatoes, sunflower seeds, cotton, and other types of products within and between workshops. These have different designs depending on their characteristics. At cotton processing enterprises, elevators with various working components and other types of equipment of varying lengths and angles of inclination are used to transfer cotton and seeds to technological machines.

Continuous mechanical conveyors include elevators, belt conveyors, and screw conveyors, which are mainly used for transporting cotton, seeds, lint, fibrous waste, and debris. Screw (auger) conveyors are used for transporting cotton and seeds and distributing them to cotton cleaning plants, lint cleaners, cotton cleaning units, and other equipment suppliers. Mechanical continuous transport means include elevators, belt conveyors, and screw conveyors, which are primarily used for transporting cotton, seeds, lint, fibrous waste, and impurities. [1].

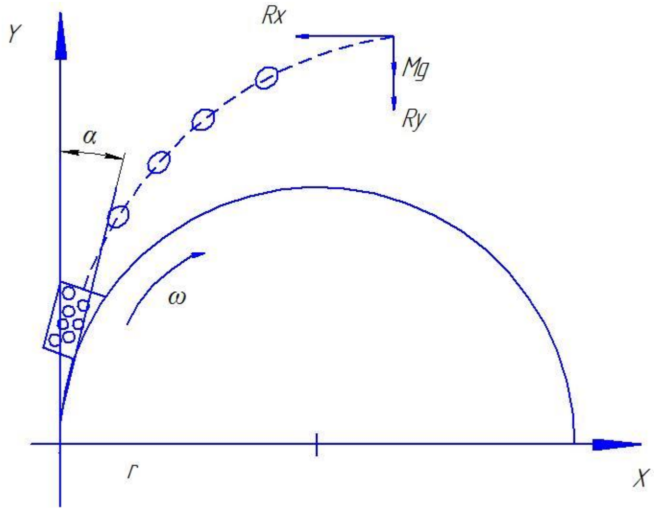
The cotton auger of the SHK type is designed for transporting cotton in a horizontal position and feeding it into the gin feed chute, cotton cleaner, and other machines. Elevators of the EKC type are used for vertical transportation of cotton, seeds, and waste at cotton processing plants. The EKC-15M1 elevator is used for transporting cotton, the ES-14M seed elevator, and the ES-14C elevator for waste are designed for transporting seeds and waste [1].

In order to prevent and reduce the damage to raw cotton and seeds, it was suggested that the seeds ejected from the elevator bucket should fall onto a belt conveyor rather than onto a metal surface [2, 3, 4].

The article establishes that the resistance of conveyor belts to tensile and weight forces, achieved by enhancing the strength of the connected or cross sections and bonding, allows for a reduction in downtime for repairs by up to 7% [5].

A new design of belt conveyors was developed by installing roller equipment in the receiving and transferring units of cotton [6, 7].

Theoretically, we will analyze the influence of the seed flow on the transfer of the seed flow under the impact of a bucket conveyor, depending on the mass of the seeds in the bucket, that is, its volume (pic. 1).



Pic. 1. Schematic diagram of seed flow on a bucket conveyor.

Let's derive the general differential equation of motion for the seeds being transported on the bucket:

$$M \cdot \ddot{x} = -R_x \cdot \vartheta_x$$
$$M \cdot \ddot{y} = -R_y \cdot \vartheta_y - M \cdot g \qquad (1)$$

where R - the force of air resistance, H.

$$R = k \cdot M \cdot g \cdot \vartheta \qquad (2)$$

where k - the coefficient of resistance; g – the acceleration due to gravity, $м/s^2$.

Let's determine the trajectories of the seed flow movement process when it detaches from the bucket under the influence of external forces.

By integrating the differential equation (1), we can determine the equations of motion for the seeds along the OX and OY axes:

$$M \cdot \ddot{x} = -k \cdot M \cdot g \cdot \dot{x}$$
$$M \cdot \ddot{y} = -k \cdot M \cdot g \cdot \dot{y} - M \cdot g \qquad (3)$$

From the differential equation (3), we obtain:

$$\frac{d\vartheta_x}{dt} = -k \cdot g \cdot \vartheta_x$$
$$\frac{d\vartheta_y}{dt} = -k \cdot g \cdot (\vartheta_y + \frac{1}{k}) \quad (4)$$

We will integrate the differential equation (4) once with respect to time and determine the velocities of the seed flow transferred by the bucket:

$$\frac{d\vartheta_x}{\vartheta_x} = -k \cdot g \cdot dt \qquad \ln \vartheta_x = -k \cdot g \cdot t + C_1$$
$$\frac{d\vartheta_y}{\vartheta_y + \frac{1}{k}} = -k \cdot g \cdot dt \quad \text{from where} \quad \ln(\vartheta_y + \frac{1}{k}) = -k \cdot g \cdot t + C_2$$

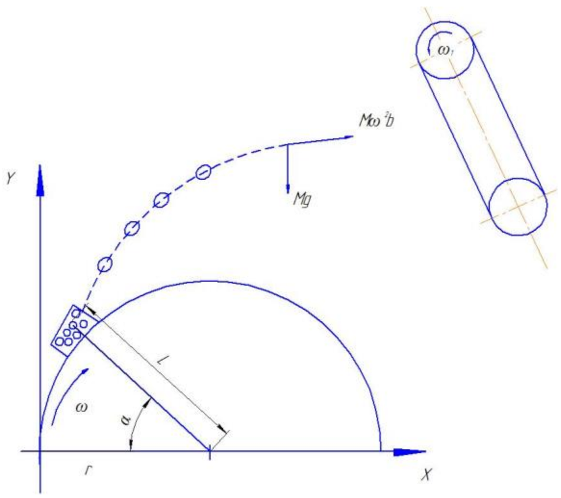
(5)

After some transformations of the obtained equations, we will formulate the trajectory equations for the movement of the seed flow transferred from the bucket elevator:

$$\frac{dx}{dt} = \vartheta_0 \cdot \cos\alpha \cdot e^{-k \cdot g \cdot t}$$
$$\Rightarrow$$
$$\frac{dy}{dt} = (\vartheta_0 \cdot \sin\alpha + \frac{1}{k}) \cdot e^{-k \cdot g \cdot t} - \frac{1}{k}$$

$$X = \frac{\vartheta_0 \cdot \cos\alpha}{k \cdot g} \cdot e^{-k \cdot g \cdot t} + C_3$$
$$Y = (\vartheta_0 \cdot \sin\alpha + \frac{1}{k}) \cdot (-\frac{1}{k \cdot g}) \cdot e^{-k \cdot g \cdot t} - \frac{1}{k} \cdot t + C_4 \quad (6)$$

We will analyze the determination of the force exerted during the transfer of the seed flow from the bucket elevator to the vibrating belt, thus reducing seed damage (pic. 2).



Pic. 2. Diagram of the seed flow movement during transfer to the vibrating belt under the influence of the bucket elevator

In this case, we determine the movement of the seeds under the influence of external forces that arise when they are ejected from the bucket.

$$J \cdot \ddot{\alpha} = -M \cdot \omega^2 \cdot L^2 + M \cdot g \cdot \cos\alpha$$

$$\frac{M \cdot L^2}{2} \cdot \ddot{\alpha} = -M \cdot \omega^2 \cdot L^2 + M \cdot g \cdot \cos\alpha \qquad (7)$$

The differential equation (7) will be simplified:

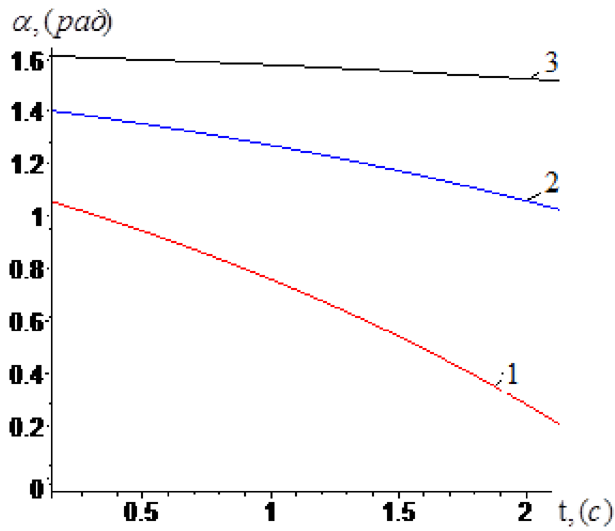
$$\ddot{\alpha} = \frac{2 \cdot g}{L^2} \cdot \cos\alpha - 2 \cdot \omega^2 \qquad (8)$$

Assuming $\cos\alpha \approx \alpha$, we will rewrite equation (8) in the following form:

$$\ddot{\alpha} - \frac{2 \cdot g}{L^2} \cdot \alpha = -2 \cdot \omega^2 \qquad (9)$$

After some transformations of the above equations, we obtain the equation of motion for the seed flow from the bucket elevator under the influence of external forces.

A graph of the dependence of the seed flow movement on time from the angle of elevator coverage by the vibrating belt, for different values of seed mass. $M_1 = 18\,gr$ $M_2 = 14\,gr$ $M_3 = 10\,gr$ is shown in pic. 3.



Pic. 3. Graph of the dependence of the seed flow movement on time from the angle of elevator coverage by the vibrating belt, for different values of seed mass.

$$M_1 = 18\,gr \; M_2 = 14\,gr \; M_3 = 10\,gr$$

As seen from the literature review and the theoretical studies conducted above, the impact of seeds ejected from the elevator buckets onto the belt conveyor results in a reduction in seed damage.

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