AMERICAN JOURNALS
Open Access, Peer Reviewed Journals

American Journal of Technology and Applied Sciences
ISSN (E): 2832-1766 Volume 48, May - 2026

DETERMINATION OF THE DEFLECTION ARC OF COTTON TUFTS CAUGHT BY THE PINS OF A LONG-PIN DRUM

Maxmud Raxmatovich Karimov
Associate Professor, Department of Transport Engineering and Logistics,
Termiz State University of Engineering and Agrotechnologies

ABSTRACT

This paper presents a theoretical investigation of the interaction between a long-pin drum and cotton tufts and their oscillatory motion in a device designed to remove stones and other heavy impurities from raw cotton. A mathematical model was developed to determine the deflection angle of a cotton tuft captured by the pins of the long-pin drum, taking into account inertial, gravitational, and aerodynamic resistance forces. A differential equation describing the relative motion of the cotton tuft was formulated and solved numerically using the Runge-Kutta method. The effects of the angular velocity of the long-pin drum and the mass of the cotton tuft on its deflection angle and oscillation amplitude were investigated. The calculated results demonstrate that increasing the angular velocity of the drum leads to an increase in the deflection angle and expansion of the cotton tuft trajectory, while a decrease in tuft mass results in a greater oscillation amplitude. Based on the obtained results, an angular speed of approximately 800 rpm is considered appropriate for reducing the probability of cotton entering the waste discharge system and improving the efficiency of heavy impurity separation. The obtained results provide a scientific and practical basis for optimizing the structural and kinematic parameters of the proposed device and improving the cleaning efficiency of raw cotton.

KEYWORDS

Raw cotton, heavy impurities, stone particles, long-pin drum, cotton tuft, deflection angle, oscillation amplitude, angular velocity, inertial force, aerodynamic resistance, mathematical model, Runge-Kutta method.

Introduction

The main active working element of the proposed device for separating heavy impurities from raw cotton is a long-pin drum. Cotton tufts entering the chamber of the device at a certain velocity are caught by the pins of the long-pin drum. This occurs because the linear velocity of the drum is higher than the velocity of the cotton flow. As a result, the cotton tufts move together with the pins for a certain period of time and acquire additional acceleration corresponding to the rotational speed of the drum.

It should be particularly emphasized that as the angular or linear velocity of the long-pin drum increases, the deflection angle of the cotton tufts retained by the pins also increases. At the same time, their vibration amplitude increases, resulting in a wider trajectory of motion. Consequently, the angle

of the direction in which the cotton tufts detach from the drum pins also increases. This phenomenon directly affects the efficiency of the heavy-impurity separation process. Therefore, determining the deflection angle of the cotton tufts on the pins of the long-pin drum is one of the important issues in the study of the separation process.

The calculation scheme developed to determine the deflection angle of a cotton tuft caught by the pins of the long-pin drum in the device designed for separating heavy impurities from raw cotton is presented in Figure 1.

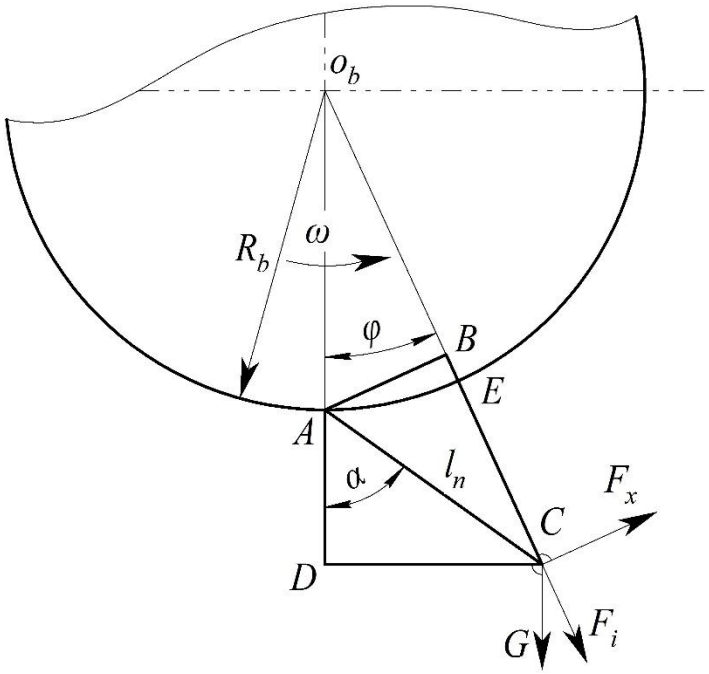


Figure 1. Calculation scheme for determining the deflection angle of a cotton tuft caught by the pins of a long-pin drum

Based on the calculation scheme shown in Figure 1, taking moments about point A of the inertia force, gravitational force, and aerodynamic drag force acting on the cotton tuft, and applying the equilibrium condition [1, 2], we obtain:

$$\sum_{i=1}^{n} M_A(F_i) = 0$$

$$-F_V \cdot AB - G \cdot DC + F_X \cdot BC = 0 \qquad (1)$$

Here, AB, DC, and BC are the moment arms of the respective forces acting about point A.

The relative inertia force [3]:

$$F_i = m_p l_n \omega^2 \qquad (2)$$

Here, m_p, l_n - are the mass and length of the cotton tuft, respectively;

ω_b- is the angular velocity of the drum.

The gravitational force [3]:

$$G = m_p g \qquad (3)$$

Aerodynamic drag force [4]:

$$F_X \frac{1}{2} F_m k_l V^2 \rho_X l_n \qquad (4)$$

Here: F_m - Cross-sectional area of the midsection;
k_l - Drag coefficient;
ρ_X - Air density;
V_p - Relative velocity of the cotton tuft.
The drag force is directed along AC, and its moment about point A is equal to zero.
According to the calculation scheme, the following can be written: [4]:
AB = R_b -$sin\varphi$, AD =$l_n cos\alpha$, DE = l_n $sin\varphi$,
Accordingly, from △ABC:
AB =l_n sin(α-φ)
BC = l_n cos(α-φ)

$$O_b C = \frac{O_b}{\cos\varphi} = \frac{R_b + l_n \cos\alpha}{\cos\varphi}$$

In this case, $O_b C = \frac{O_b}{\cos\varphi} = \frac{R_b + l_n \cos\alpha}{\cos\varphi}$ (5)

Taking into account the correspondence between the oscillatory motion of the cotton tuft and the oscillation of a suspended pendulum, as well as the studies of Ya. B. Panovko [5], the relative velocity of the cotton tuft can be expressed by the following differential equation:

$$m_p l_{n^2} \frac{d^2\alpha}{dt^2} = m_p \omega^2 \frac{R_b + l_n \cos\alpha}{\sin\varphi} - m_p g \frac{R_b + l_n \cos\alpha}{\sin\varphi} + \frac{1}{2} F_m k_l \rho_X V_p l_n{}^2 \sin(\alpha - \varphi) \qquad (6)$$

The numerical solution of Equation (6) was obtained using the following parameter values:
m_p=(0,38÷0,44) 10^{-2} kg; ω_b =(700÷800) ayl/min;R_b =(2,0÷2,2)10^{-1} m;
l_n= (2,0÷2,5)10^{-2} m; g=9,81m/s^2; V_p =(8,0÷10,0) m/s;
ρ_X =(0,2÷0,5)g/sm^3.

The numerical solution of the problem was performed on a computer using the Runge-Kutta method. The computational results were obtained using a computer program, and the patterns governing the variation of the process parameters were determined.
In analyzing the obtained solutions, it is important not only to determine the variation of the angle α over time, but also to establish its maximum oscillation amplitude. Based on the analysis of the values of Δα, it becomes possible to determine the deflection angles of the cotton tuft as a function of the angular velocity of the long-pin drum.

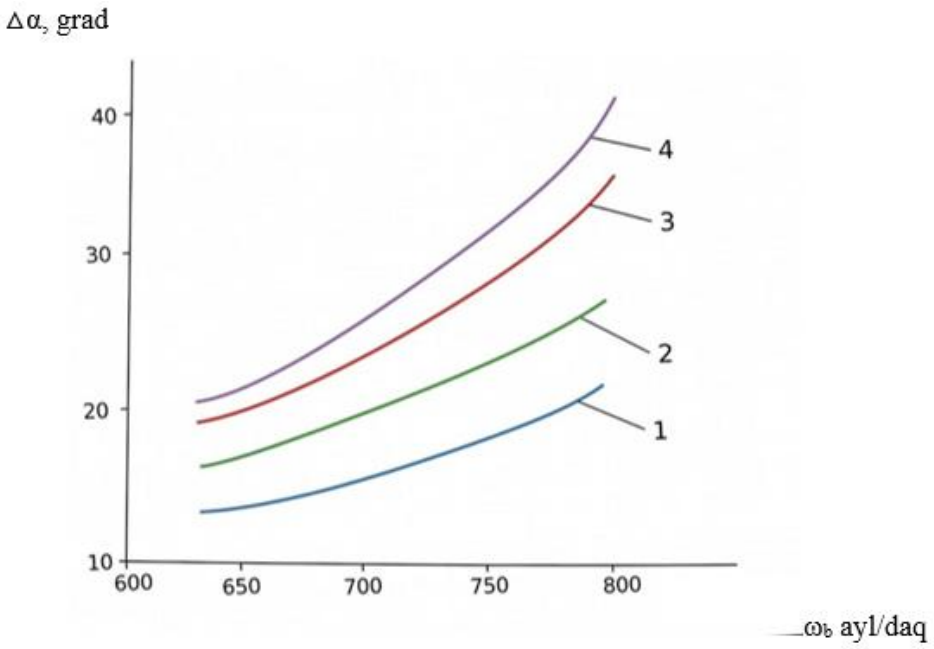


Figure 2. Graphs showing the dependence of the range of the oblique oscillation angle of the cotton tuft relative to the point of attachment to the pins of the long-pin drum on the variation in the angular velocity of the drum

1- m_p=0,810·10^{-3} kg; 2- m_p =0,6·10^{-3} kg; 3- m_p =0,4·10^{-3} kg; 4- m_p =0,2·10^{-3} kg.

Figure 2 presents graphs illustrating the dependence of the range of the oblique oscillation angle formed by the cotton tuft relative to the point of its attachment to the pins of the long-pin drum on the variation in the angular velocity of the drum. These graphs make it possible to evaluate the motion characteristics of the cotton tuft and to select appropriate parameters for the operating mode of the drum.

In the proposed heavy-impurity separation device, in order to prevent cotton tufts from entering the waste stream through the vacuum valve intended for removing heavy impurities, it is considered appropriate to use cotton tufts of relatively low mass and to select the rotational speed of the long-pin drum at approximately 800 rpm. When the cotton tufts are effectively loosened by the long-pin drum, the heavy impurities contained within them are separated more efficiently. As a result, the probability of the lighter and well-loosened cotton tufts being carried into the waste stream is significantly reduced. However, the moisture content of the cotton tufts was not taken into account in this theoretical analysis. It is known that an increase in cotton moisture content also increases its mass, which may affect the motion process and, to some extent, the separation efficiency. Therefore, the effect of the moisture factor should be investigated and evaluated on the basis of experimental studies.

The operating principle of the proposed device for separating stones and other heavy impurities from raw cotton was theoretically substantiated as being based on the interaction between the long-pin drum and the cotton tufts. It was established that, due to the linear velocity of the drum being higher than the velocity of the cotton flow, the cotton tufts are caught by the pins and move together with the drum for a certain period of time.

For the oscillatory motion of the cotton tuft on the pins of the long-pin drum, an equilibrium equation and a differential equation of motion were formulated by taking into account the inertia force,

gravitational force, and aerodynamic drag force acting on the tuft. This mathematical model makes it possible to determine the deflection angle of the cotton tuft and the pattern of its variation with time. The calculations performed using the Runge-Kutta numerical method determined the effects of the angular velocity of the long-pin drum, the mass of the cotton tuft, and other parameters on its oscillation amplitude and deflection angle. The calculation results showed that, with an increase in the angular velocity of the drum, the deflection angle, oscillation amplitude, and motion trajectory of the cotton tuft increase accordingly.

References

1. Targ, S.M. A Short Course in Theoretical Mechanics. Moscow: Nauka, 1967. 478 p.
2. Development of Equipment for Capturing Stones and Other Heavy Impurities Contained in Raw Cotton. Scientific Report No. 20-05. “Paxtasanoat ilmiy markazi” JSC, 2020. 30 p.
3. Mansurova, M.A., Madrakhimov, Sh., & Umarova, Z.M. (2016). Analysis of the influence of the lengths of the coupler and rocker arm links on the position of the flat four-link mechanism. *Theory of Mechanisms and Machines*, 14(2), 21–29.
4. Djuraev, A. Dynamics of Working Mechanisms of Cotton-Processing Machines. Tashkent: Fan Publishing House of the Uzbek SSR, 1987. 168 p.
5.Panovko, Ya.G. Fundamentals of the Applied Theory of Oscillations and Impact. Moscow: Mashinostroenie, 1976. 320 p.