Study of the coefficient of friction caused by the seed cotton flow action in pneumatic polyethylene pipes

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Abstract. This study aimed to improve the quality indicators of cotton by replacing traditional steel pipes with polyethylene pipes in cotton ginning enterprises. The research involved adding erucamide product to the polyethylene composition and applying it to the cotton ginning process. The damage processes to cotton fibers during the seed cotton flow action in pneumatic steel pipes were studied. The installation of polyethylene pipes was found to significantly improve the quality of the chipboard. The advantages and disadvantages of using polyethylene pipes were considered, and the damage levels to cotton fibers were assessed. The results highlight the benefits of using polyethylene pipes in cotton ginning enterprises to produce high-quality cotton fibers and seeds.

1 Introduction

Nowadays, one of the requirements for cotton ginning enterprises is aimed at preventing damage to cotton fibers during production processes. A pneumatic piping conveyor becomes even more important in the factory as new conditions for preparing and storing cotton raw materials are introduced, and cotton-growing farms need separate storage areas for raw materials according to their selection and technical characteristics. This is why the new system includes larger storage areas and allows transport devices to move across a wider range of areas. [1].

It's critical to research why the cotton is impacted during its working surfaces by the pneumatic piping systems used in the pneumatic transport system. The raw cotton material moves unevenly rather than uniformly inside the seed cotton handling devices. This caused different cottons to collide with the pneumatic pipe's walls, damaging the seeds within. The natural characteristics of the raw cotton material may be preserved and the method of transportation can be made more efficient by altering the pneumatic pipes, which is a vital part of pneumatic transport. Furthermore, it will be feasible to prevent air leaks from pneumatic pipes by making sure they are properly connected, which would reduce air consumption [2].

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2 Materials and methods

At the "Jizzakh Polyethylene Production" manufacturing plant, erucamide was blended into high-density polyethylene to form a great deal heat and pressure-resistant polyethylene pipes with a diameter of up to 400 mm, which were thereafter used to research the damage qualities of cotton fiber [3-5].

The cotton raw material vibrations along the airflow in the bottom section of the pipe, according to the moisture content of the airflow and the composition of the air mixture. The raw cotton distributes rather consistently over the pipe cross-section at high air flow rates (above 25.0 m/s), and the majority of the transport is suspended in the air [6-8].

When the air velocity decreases from 25.0 m/s, redistribution of the material in the pipe section occurs. Its maximum amount is in the lower section of the pipe and decreases along the upper direction [9].

Thus, if the winding speed is a boundary condition in a vertical pipe, then in a horizontal pipe, the traction and flight velocities are the boundary conditions, or they are also called spreading and sliding speeds [10].

For ease of use, we start the coordinate at the beginning of the pneumatic conveying systems while examining the movement of the cotton in the suction portion of the pipe. Assume for the moment that the particle is moving between two indefinite limitations:

$$u=0 \text{ and } u=h. \quad (1)$$

Assume that the cotton piece goes at a certain angle to the pneumatic pipe's axis and has an absolute velocity when it comes into contact with the air stream. After that, the motion equation will be:

$$\begin{cases} m\ddot{x} = -k(\dot{x} - \vartheta) \\ m\ddot{y} = k\dot{y} - mg \end{cases} \quad (2)$$

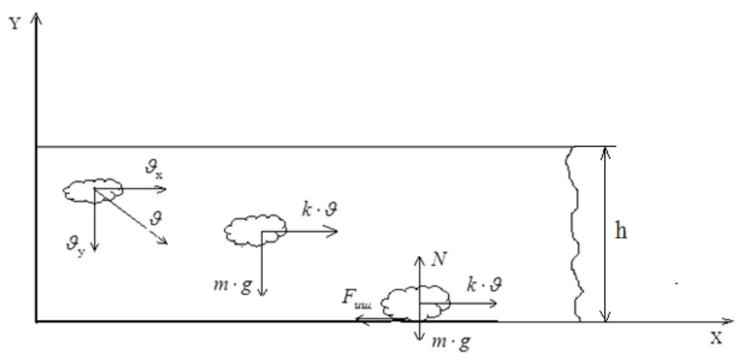


Fig. 1. The scheme of cotton flow action inside the pneumatic pipe.

$\vartheta_x = \frac{dx}{dt}and\vartheta_y = \frac{dy}{dt}$ taking into account, that we integrate the system (2) under the condition t=0. The solution would be:

First, we integrate the cotton flow along the OX axis.

$$m \cdot \ddot{x} + k \cdot \dot{x} = k \cdot \vartheta \quad (3)$$

(3) is a second-order inhomogeneous linear equation. Its general solution is equal to the sum $m \cdot \ddot{x} + k \cdot \dot{x} = 0$of the general solution of the homogeneous equation $x_1 = e^{\lambda \cdot t}$and the particular solution of equation (3)$x_2 = A \cdot t + B$.

$$x = x_1 + x_2 \quad (4)$$

(4) is determined by substituting the general and particular solutions of the equation and using the initial and boundary conditions for the constant values. We derive the general form of the equation.

$$x = -\frac{m}{k} \cdot (\vartheta_x \cdot \cos\alpha - \vartheta) \cdot (1 - e^{-\frac{k}{m} \cdot t}) \quad (5)$$

(5) represents the equation of motion along the OX axis of cotton flow in a plastic pipe. We express the movement of cotton flow along the OY axis in the pipe.

$$m\ddot{y} - k\dot{y} = -mg \quad (6)$$

(6) is an inhomogeneous linear equation of second order. Its general solution is equal to the sum $m\ddot{y} - k\dot{y} = 0$of the general solution of the homogeneous equation $y_1 = e^{\lambda \cdot t}$and the particular solution of equation (6)$y_2 = A \cdot t + B$. We derive the general form of the equation.

$$y = \frac{m}{k} \cdot (\vartheta_x \cdot \sin\alpha - \frac{m \cdot g}{k}) \cdot (1 - e^{\frac{k}{m} \cdot t}) + h\chi \quad (7)$$

Equation (7) represents the flow behavior of cotton in a plastic pipe.

Based on analytical calculations, (x, y) we determine the expression of the speed of the piece of cotton after the impact and its location on the coordinate axes:

$$\begin{cases} \vartheta_x == \vartheta \cdot l \cdot \cos\alpha - \frac{k}{m}(t - t1) + \vartheta \\ \vartheta_y = \left(\vartheta \cdot \sin\alpha - \frac{mg}{k}\right) l - \frac{k}{m}(t - t1) + \frac{mg}{k} \end{cases} \quad (8)$$

Equations (5), (7), and (8) determine the state of impact of a cotton ball on the wall of a polyethylene pipe. In this case, the particle reaches a critical point and falls. If the magnitude of the vertical coordinate of the critical point is greater than the diameter of the pipe, then the fragment hits the upper wall. Its next state can be determined with sufficient accuracy by equations of the form (5), (7) and (8). Only changes are made to take into account the direction of the initial velocity after the impact.

3 Results and discussion

As a result of subtracting $y = y(t)$ time from expressions (5) and (7)t, the law of change of the trajectory of a piece of cotton along the diameter and length of a plastic pipe is depicted graphically.

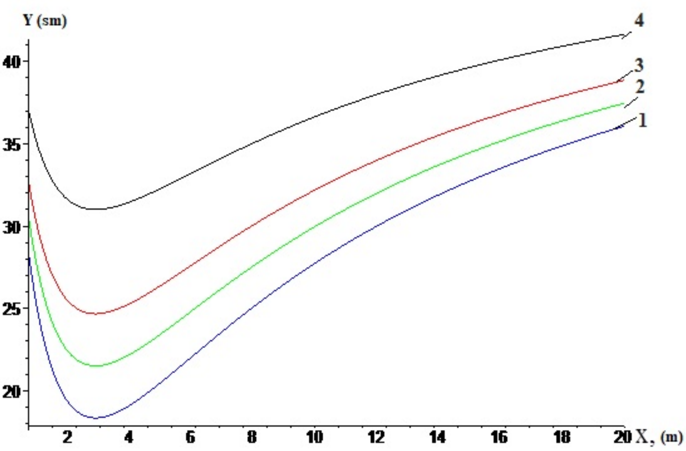
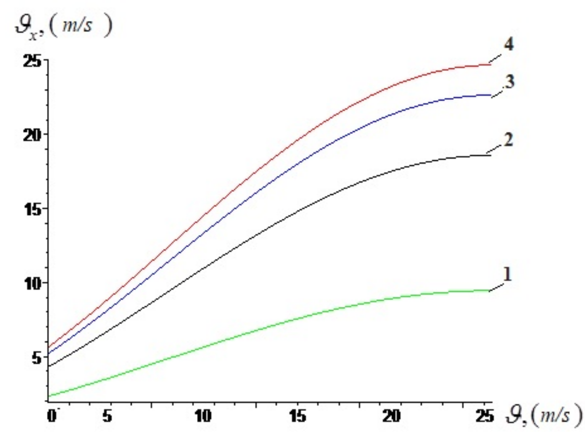


Fig 2. Pipes of different diameters $d_1 = 30\ sm, d_2 = 35\ sm, d_3 = 40\ sm, d_4 = 45sm$ in values graph of the movement of cotton balls against time.

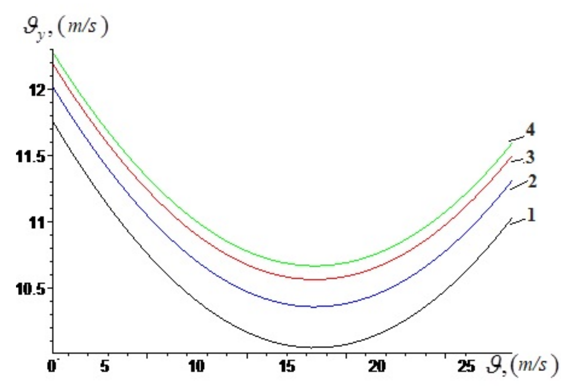
As the graph illustrates, even in the absence of consideration for the longitudinal, rotational, and other flow forces, a piece of cotton will nonetheless touch the polyethylene pipe wall when it moves through the pipe. If a blow is made at this pace, it will be considerably more intense and faster, making q much larger. Because the pipe in this instance is made of polyethylene, there is less chance of damage to the seed because there is less friction between the cotton fragments and the polyethylene pipe's surface [6].

(Using the Maple-6 application, graphs representing the cotton ball's impact speed on the polyethylene pipe wall and its impact angle on the surface of the pipe are displayed based on equation 2.



1 - $\alpha_1 = 30^0$; 2 - $\alpha_1 = 45^0$; 3 - $\alpha_1 = 60^0$; 4 - $\alpha_1 = 75^0$.

Fig 3. Dependence of the impact speed of the cottonseed along the axis OX and the angle of impact of the plastic pipe to the surface.



1 - $\alpha_1 = 30^0$; 2 - $\alpha_1 = 45^0$; 3 - $\alpha_1 = 60^0$; 4 - $\alpha_1 = 75^0$.

Fig 4. Dependence of the plastic pipe's impact angle with in regard to the surface and the seed's impact speed on the diameter of the seed cotton along the OU axis.

The pneumatic systems, damage to the seeds also increases, which causes a decrease in the quality of the cotton fiber, and in the preparation of the seeds for planting, its fertility decreases. Therefore, it is important to study the effect of the geometric shape of the networks on the degree of injury of cotton seeds being transported. In the recommended polyethylene pipe, as a result of the movement of the cotton stream, damage to the seeds is reduced, due to which the friction on the surface of the plastic pipe is reduced [7].

It is important to study the influence of the degree of damage of raw cotton seeds during the curved movement of cotton pieces in the polyethylene pipe. By increasing the speed of cotton raw material transportation in the pneumatic transport device, damage to seeds also increases, which reduces the quality of cotton fiber. To determine the speed of a piece of cotton moving along a curved line in the interval AV at point S, we use the theorem about the change in kinetic energy [8].

4 Conclusion

A differential equation was developed to investigate the flow of raw cotton material within a polyethylene conduit. The trajectory of the cotton ball entering the polyethylene tubing was ascertained by solving the differential equation. Determining the cotton ball's impact force on the pipe walls was made achievable by the movement trajectory. A graph was created to show how the diameter of the pipe and airspeed affected the cotton flow in the pipe and how long it took to move. At various speed settings, the cotton movement in the pipe was shown on a time dependency graph. Time graphs showing the weight of the cotton piece at various pipe diameters were developed.

References

1. R.M. Muradov, Journal Problem of mechanics **1** (2003)
2. Akbar Abrorov et al., Journal of Physics: Conference Series **2573** 012038 (2023)
3. G. Kadirova, E3S Web of Conferences **486** 01019 (2024)
4. A. Amanov, Sh.R. Khurramov, G.A. Bahadirov, A. Abdukarimov, T.Y. Amanov, Journal of Leather Scince and Engineering **3(14)** (2021)
5. Sh.R. Khurramov, F.S. Khalturaev, F.Z. Kurbanova, Journal of Physics: Conference Series **2373** 072002 (2022). https://www.doi.org/10.1088/1742-6596/2373/7/072002
6. E. Saribaev, A. Abrorov, B. Otaboev, N. Sariboev, A. Daliev, Journal of Physics: Conference Series **2388** 012174 (2022)
7. M. Rustam, I. Khamidullo, K. Khusanboy, Engineering **14(03)**, 119-130 (2022)
8. Sh.R. Khurramov, G.A. Bahadirov, A. Abdukarimov, News of Higher Educational Institutions, Series Technology of Textile Industry **1(397)**, 242-246 (2022)
9. M. Salomova, M. Salokhiddinova, R. Muradov, A. Kushimov, AIP Conf. Proc. **2789** 040045 (2023). https://doi.org/10.1063/5.0145641
10. F. Rahimov, X. Kosimov, R. Muradov, N. Gadayev, AIP Conf. Proc. **2789** 040034 (2023). https://doi.org/10.1063/5.0145669