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Research Article

OPTIMIZATION OF THERMAL-ELECTRIC TRANSPORT OF THE INTERFACE IN THE Cdte/Cds – Bi_2Te_3/Sb_2Te_3 MONOLITHIC SYSTEM

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ABSTRACT

This paper presents a theoretical analysis of the motion of fuzzy cottonseed flow in an inclined mixing drum using a system of differential equations. The dynamic behaviour of the cottonseed flow is modelled by considering the effects of normal pressure and resistance forces acting on the particles during the mixing process. Special attention is paid to the influence of frictional and resistive forces on maintaining the continuity and stability of the fuzzy cottonseed flow when seed cotton is mixed with a chemical suspension.

The study examines how the inclination angle of the mixing drum affects pressure distribution, resistance forces, and the overall flow regime of fuzzy cottonseed. The interaction between cottonseed particles and the drum surface is analysed to identify key factors governing efficient mixing and uniform coating during seed treatment operations. The obtained theoretical results provide a basis for optimizing the design and operating parameters of inclined mixing drums, contributing to improved process efficiency and reduced energy consumption.

Keywords

Fuzzy cottonseed; inclined mixing drum; flow modelling; inclination angle; normal pressure; resistance forces.

Introduction

For high-quality seed cotton treatment, technological equipment must be properly adjusted in accordance with specified operating parameters. One of the main working components of seed cotton treatment machines is the mixing drum, which plays a decisive role in ensuring uniform distribution of the chemical suspension over the seed surface [1].

The installation angle of the mixing drum relative to the horizontal plane is an important parameter that directly affects both the quality of seed treatment and the productivity of the machine. Changes in the inclination angle influence the movement pattern of fuzzy cottonseed, the residence time of particles inside the drum, and the uniformity of mixing. Therefore, an accurate theoretical analysis of the cottonseed flow behavior in an inclined mixing drum is required to optimize the operating conditions of the equipment.

In this study, the motion of fuzzy cottonseed flow in an inclined mixing drum is modeled using differential equations, taking into account the effects of normal pressure and resistance forces acting on the particles. The analysis focuses on identifying the influence of these forces on the stability and continuity of the flow during the mixing process. The general principles governing the motion of granular and bulk materials, as well as theoretical approaches to mixing processes in drum-type devices, are adopted as the theoretical basis of the research [2].

Materials and Methods

The motion of fuzzy cottonseed flow in an inclined mixing drum during the mixing of seed cotton with a chemical suspension is analyzed by considering the effects of frictional and resistance forces that ensure the continuity of the flow. The interaction between the cottonseed particles and the drum surface under the action of external forces is examined to describe the dynamic behavior of the flow (Figure 1).

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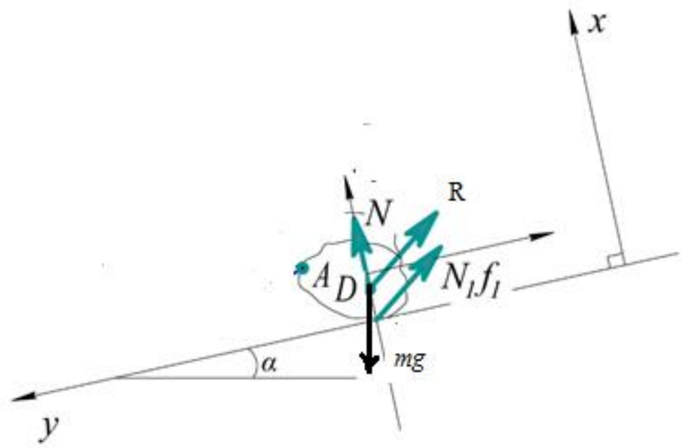

Figure 1. Schematic representation of the motion of fuzzy cottonseed flow under the action of external forces in an inclined mixing drum.

The equations of motion describing the behavior of the fuzzy cottonseed flow under the influence of external forces during its transportation through the inclined mixing drum were formulated using differential equations based on the principles of granular material mechanics. The model accounts for friction forces arising from contact between the cottonseed particles and the drum surface, as well as resistance forces opposing the flow movement. These forces play a key role in maintaining a stable and continuous flow regime during the mixing process. The theoretical framework applied in this study relies on established concepts of bulk material mechanics and mixing processes in drum-type devices [3].

$$m\frac{d^2y}{dt^2} = m\cdot g\cdot\sin\alpha - N_1\cdot\cos\alpha - R\cdot f_1\frac{\vartheta_{Dy}}{\vartheta_D} - N_1 f_1\frac{\vartheta_{Ay}}{\vartheta_A}$$

$$m\frac{d^2x}{dt^2} = N\cdot f_1\cdot\frac{\vartheta_{Ax}}{\vartheta_A} \quad (1)$$

From the system of differential equations (1), the ratios of the velocities of the fuzzy cottonseed flow on the surface of the mixing drum are expressed as follows.

$$\frac{\vartheta_{Ay}}{\vartheta_A} = 0; \qquad \frac{\vartheta_{Dy}}{\vartheta_D} = 1 \quad (2)$$

The velocity ratios of the fuzzy cottonseed flow given in equations (2) are substituted into the differential equation (1).

$$\begin{aligned} m\cdot y &= m\cdot g\cdot\sin\alpha - N_1\cdot\cos\alpha - R\cdot f_1 \\ m\cdot x &= R + N\cdot f \\ m\cdot z_c &= -m\cdot g\cdot\cos\alpha - N_1\cdot\sin\alpha \end{aligned} \quad (3)$$

Since the velocities on the surface of the mixing drum remain constant with respect to time, the condition is satisfied.

$$m\cdot g\cdot\sin\alpha - N_1\cdot\cos\alpha - R\cdot f_1 = 0 \quad (4)$$

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$$R + N_1 \cdot f_1 - N \cdot f_1 = 0$$
$$-m \cdot g \cdot \cos\alpha - N_1 \cdot \sin\alpha - N = 0 \qquad (5)$$

From equations (4), expressions describing the dependence of the normal pressure forces and the resistance force acting on the fuzzy cottonseed flow on the inclination angles of the mixing drum and the friction coefficients are obtained.

$$N_1 = \frac{m \cdot g \cdot (1 - f_1 \cdot f_2 \cdot \cos\alpha)}{f_1^2 (1 - \cos\alpha)}$$
$$R = \frac{m \cdot g \cdot f_1 \cdot (\sin\alpha - 1)}{f_1^2 \cdot (\sin\alpha - \cos\alpha)} \qquad (6)$$

Using the expressions obtained from equations (5), which describe the dependence of the normal pressure forces and the resistance force acting in an inclined mixing drum on the inclination angle, friction coefficients, and the mass of the fuzzy cottonseed flow, the resulting graphs of external force effects were analyzed using the Maple software.

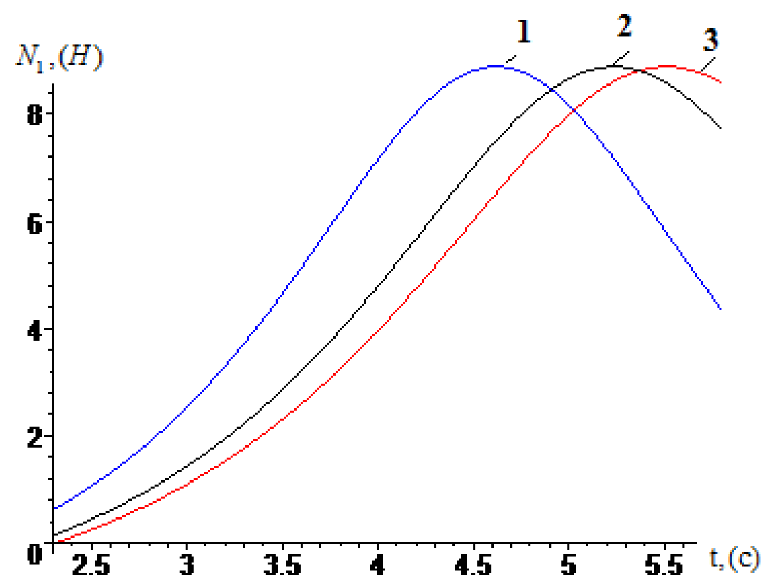

Figure 2. Time-dependent variation of the normal pressure force acting on the motion of the fuzzy cottonseed flow in an inclined mixing drum at different inclination angles for various values of $\alpha_1 = 15^\circ;\ \alpha_2 = 10^\circ,\ \ \alpha_3 = 5^\circ$ **.**

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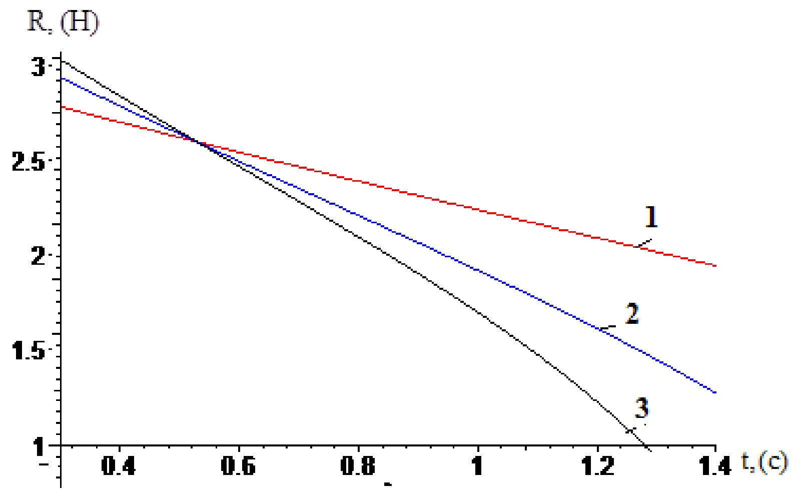

Figure 3. Time-dependent variation of the resistance force acting on the motion of the fuzzy cottonseed flow in an inclined mixing drum at different inclination angles for various values of $\alpha_1 = 15^\circ;\ \alpha_2 = 10^\circ,\ \ \alpha_3 = 5^\circ$.

Conclusions

In conclusion, the graphs presented above illustrate the variation of the normal pressure force and the resistance force resulting from the motion of fuzzy cottonseed flow in an inclined mixing drum. The analysis shows that when the mixing drum is installed at a certain inclination angle relative to the horizontal plane, the normal pressure force acting on the fuzzy cottonseed flow increases uniformly, while the resistance force decreases uniformly.

Such a redistribution of forces promotes a more uniform spreading and stable movement of the fuzzy cottonseed flow along the drum surface. As a result, the efficiency of mixing seed cotton with the chemical suspension is significantly improved. The obtained results confirm that the rational selection of the inclination angle of the mixing drum plays a crucial role in enhancing the technological effectiveness of seed treatment processes and ensuring uniform coating of the cottonseed.

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