

GENERATION OF PONDEROMOTOR FORCES IN A DIELECTRIC SORTING MACHINE WITH AN AUXILIARY ELECTRODE SYSTEM

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Abstract:

Purpose: This article is devoted to studying the generation, nature, and role of ponderomotor forces in dielectric sorting machines. Ponderomotor forces arise due to the charging of cotton seeds under the influence of an electric field and the differences in their dielectric properties. These forces enable the movement of seeds and their separation into various fractions. The article analyzes the dependence of ponderomotor forces on factors such as electric field strength, dielectric properties of seeds, degree of charging, and weight.

Methods. The article investigates the processes of high-quality sorting and processing of cotton seeds using dielectric sorting technologies. The formation of ponderomotor forces and their dependence on seed charging and dielectric properties have been studied. These forces play a crucial role in separating seeds into different fractions, thereby improving quality and efficiency in agriculture.

Results. Dielectric sorting machines separate cotton seeds based on differences in their charging behavior and dielectric properties. Ponderomotor forces, generated under the influence of an electric field, enable the segregation of seeds into distinct fractions. Research demonstrates that these forces depend on factors such as electric field strength, the dielectric properties of seeds, their charge level, and mass. The adoption of this technology in Uzbekistan expands opportunities to enhance both cotton cultivation and processing, yielding higher-quality products.

Conclusion. Dielectric sorting devices hold significant potential for high-precision seed separation. Ponderomotor forces arise from the combined effects of electric field-induced seed charging and variations in dielectric properties. These forces govern seed movement and enable their classification into targeted groups. Studies confirm that ponderomotor forces are influenced by electric field intensity, seed dielectric characteristics, charge accumulation, and particle mass.

Keywords: seed, dielectric separation, electrode, ponderomotor forces, electric field strength, charge, electric field.

Introduction

In modern agriculture, high-quality sorting and processing of agricultural products are of paramount importance. Particularly in cotton cultivation and processing, the separation of high-quality seeds and the removal of defective ones are among the key factors in improving productivity. Today, dielectric sorting technologies are widely used in many countries worldwide, including the United States, China, India, and European nations. These technologies leverage differences in the dielectric properties of materials to enable precise and rapid sorting.

Global researchers are actively conducting scientific studies on dielectric sorting machines and their working principles. For instance, in the U.S. and Europe, new methods for high-quality sorting of grains, seeds, and other agricultural products are being developed using dielectric sorting technologies. In China, these technologies are applied to sort medicinal plant seeds, while in India, dielectric sorting machines have demonstrated effective results in separating damaged and healthy cotton components [1].

Methods.

This study investigates the generation of ponderomotor forces in dielectric sorting machines, their nature, and their role in the sorting process of seeds. Ponderomotor forces are formed as a result of the charging of seeds under the influence of an electric field and differences in their dielectric properties. These forces allow the movement of seeds and their separation into different fractions. The results of the research suggest new solutions for high-quality sorting and processing of seeds, which will help to increase quality and efficiency in agriculture. Ponderomotor forces and their nature are described in a number of ways. These forces are directly related to the strength and direction of the electric field, and the stronger the electric field, the stronger the ponderomotor force. The dielectric properties of the seed also play an important role in the formation of ponderomotor forces. Different seeds or different states of the same seed (for example, healthy and defective seeds) are charged to different degrees in an electric field, which leads to the influence of different forces on them.

The degree of charge of the seed determines the magnitude of the ponderomotor forces. Seeds with a large surface area are more highly charged and therefore are subject to a stronger ponderomotor force. In addition, ponderomotor forces also depend on the weight of the seed. Lighter seeds move faster under the influence of an electric field, while heavier seeds move slower. This difference makes it possible to separate seeds according to their qualities and properties [2-3].

Results.

Ponderomotor forces can move the seeds in a specific direction depending on the direction of the electric field. This feature is used in the sorting process to

separate seeds into different fractions. The nature of the forces may be linear or nonlinear depending on the strength of the electric field and the properties of the seed. For example, in small electric fields, the forces are linear, but in large fields, this relationship may become more complex [4-6].

Ponderomotor forces are formed under the influence of the electric field, depending on the charging of the seeds and their physical properties. These forces allow accurate separation of seeds based on their quality and properties and are considered the main mechanism of dielectric sorting technologies [5-9].

Determining ponderomotor forces:

$$\vec{F}_{эл} = K_{\phi} E \text{grad} E \quad (1)$$

Where K_{ϕ} - is the coefficient that accounts for the influence of the shape and dielectric permeability of the particle on the dipole moment value.

In a specific case for a spherical particle:

$$K_{\phi} = 4 \pi \varepsilon_0 R^3 \frac{\varepsilon_2 - \varepsilon_1}{\varepsilon_2 + 2 \varepsilon_1} \quad (2)$$

R- radius of the dielectric particle.

By substituting the electric field E and its gradient $\text{grad}E$ into the equation, we derive the function of ponderomotor force for a system of conductors with variable polarity.

For the condition $R \ll a$ the following formula is derived:

$$\vec{F}_{эл} = \frac{-K_{\phi} \pi \tau^2}{8 \varepsilon_0^2 \varepsilon_1^2 a^3} \vec{i}$$

The minus sign before formula (3) indicates that the ponderomotor force is directed opposite to the unit vectors $\vec{i}$ and $\vec{j}$ in the case where $\varepsilon_2 > \varepsilon_1$, meaning this force is attractive and directed toward the system of conductors with variable polarity.

Here

ε_1 - relative dielectric permittivity of the medium;

ε_2 - relative dielectric permittivity of the particle.

We determine the action zone of the ponderomotor force. To simplify the calculations, we pass from the vector function of the ponderomotor force to its modulus:

$$F_{эл} = \frac{K_{\phi} \pi \tau^2}{8 E_0^2 E_1^2 a^3} \cdot \vec{i} \vec{i}$$

We also check the change of $F_{\text{эл}}$ along the y -axis at ordinates $x=0$ and $x=0.5a$. Furthermore, we observe the change of $F_{\text{эл}}$ along the x axis when $y=0$ in the inter-electrode space.

When $x=0$ along the y -axis:

$$F_{\text{эл}1y} = \frac{K_{\phi} \pi \tau^2}{4 \varepsilon_0^2 \varepsilon_1^2 a^3} \cdot \frac{ch \frac{\pi}{a} y}{sh^3 \frac{\pi}{a} y}$$

It can be seen from the equation that the change in the force is equal to the ratio of the hyperbolic cosine to the cube of the hyperbolic sine, and as the distance from the conductor increases, it is characterized by a sharp decrease [10].

At a distance of a between the electrodes, the force decreases to such an extent that its value can be neglected.

When $x=0.5a$ the force along y is determined by the following equation:

$$F_{\text{эл}2y} = \frac{K_{\phi} \pi \tau^2}{4 \varepsilon_0^2 \varepsilon_1^2 a^3} \cdot \frac{sh \frac{\pi}{a} y}{ch^3 \frac{\pi}{a} y}$$

In this case, the change in force is determined by the ratio of the hyperbolic sine to the cube of the hyperbolic cosine. A characteristic feature of this ratio is that when $y=0$ the ratio is equal to zero, i.e., at the point $Mo=(x=0.5a, y=0)$ the ponderomotor force is absent ($F_{\text{эл}2y}=0$).

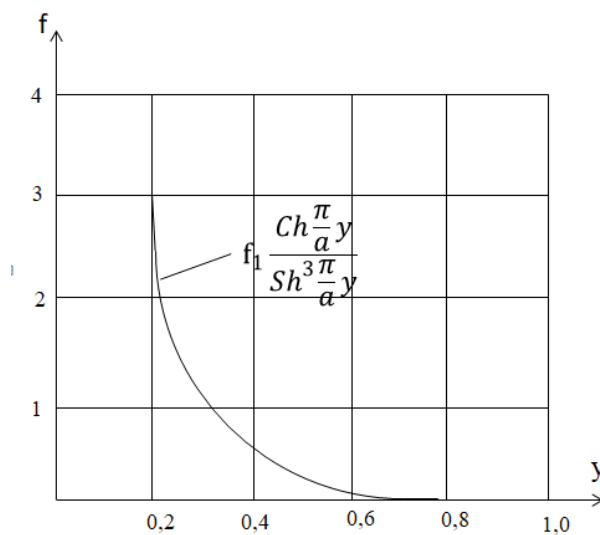


Figure 1. Graph of the function $\frac{ch \frac{\pi}{a} y}{sh^3 \frac{\pi}{a} y}$ representing the change in the

component of the ponderomotor force as the distance from the system of conductors increases along the y -axis.

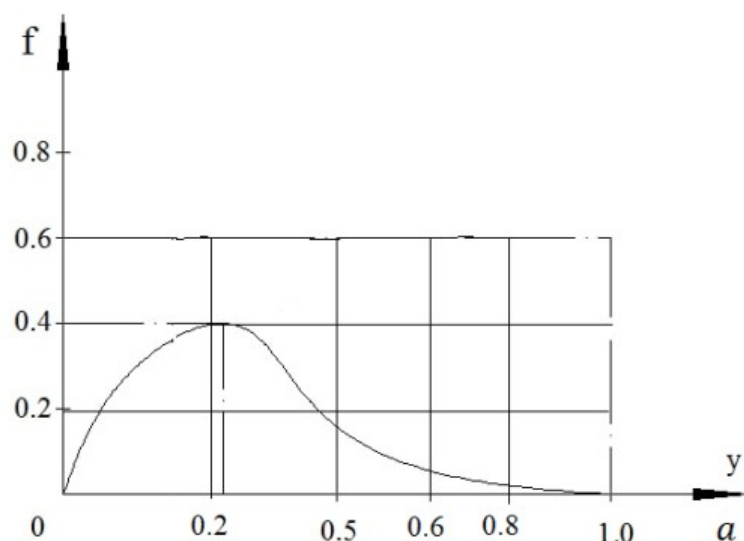


Figure 2. Graph of the change in the ponderomotor force function as it moves away from the system of alternating conductors at $x=0.5a$.

Discussions.

First of all, the influence of the electric field plays a crucial role. In a dielectric sorting machine, a high-voltage electric field is generated, which causes the surface of the seeds to become charged. Healthy and defective seeds acquire different levels of charge because their dielectric constants and surface properties differ. Healthy seeds have good dielectric properties and become uniformly charged under the influence of the electric field. Defective seeds (for example, underdeveloped, damaged, or contaminated ones), on the other hand, receive less charge or are charged unevenly [12].

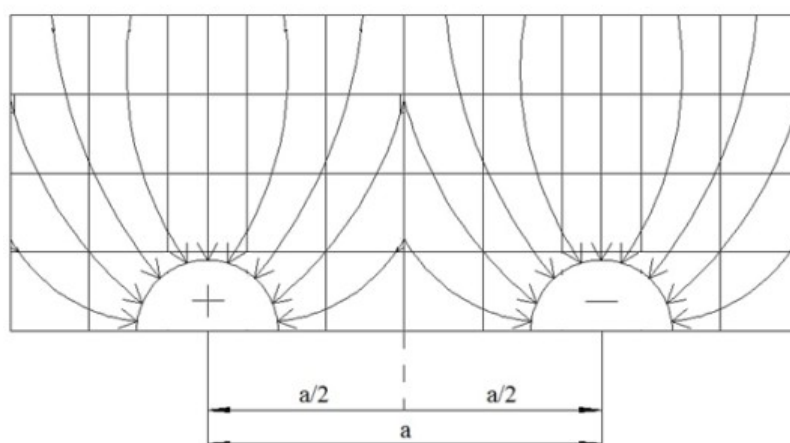


Figure 3. Illustration of ponderomotor forces in a system of alternating-polarity conductors

Figure 3 presents the depiction of ponderomotor forces in a system of alternating-polarity conductors. The tangents to these lines indicate the direction of

the force at any arbitrary point in space. As seen in the figure, the force pattern is symmetric and uniform—whether for positively or negatively charged conductors. That is, the direction of the ponderomotor force is not influenced by the sign of the charge on the conductor. The conducted calculations and their analysis characterize the behavior of finely dispersed particles in a variable-polarity field [15-16].

Dielectric sorting machines play a crucial role in the quality-based sorting of seeds. Ponderomotor forces arise due to the charging of seeds under the influence of an electric field and differences in their dielectric properties. These forces cause the seeds to move and enable their separation into various fractions. Research results show that ponderomotor forces depend on factors such as the strength of the electric field, the dielectric properties of the seeds, their charge level, and their weight.

Conclusions.

Dielectric sorting technologies offer methods to improve product quality, increase production efficiency, and ensure environmentally friendly processes in agriculture. Implementing this technology in Uzbekistan's agricultural sector will expand opportunities for obtaining high-quality products in cotton cultivation and processing. In the future, by improving and widely applying this technology, it will be possible to further enhance quality and efficiency in agriculture.

REFERENCES

1. Данко П.Е., Попов А.Г., Кожевников Т.Я. Высшая математика в упражнениях и задачах. В 2 ч. Учебное пособие для студентов вузов. 6-е изд. — М.: 2003, - С.208-210
2. Двейт Г.Б. Таблицы интегралов и другие математические формулы. Пер.с англ. Изд.4-с.- М.:Научно, 2010.-223 с.
3. Имомқулов У.Б. Тукли уруғлик чигитларни экишга тайёрлаш технологиясини такомиллаштириш //“Қишлоқ ва сув хўжалигининг замонавий муаммолари”– Тошкент, 2018. – Б. 334-336.
4. Иофинов С.А., Лышко Г.П. Индустриальная технология возделывания сельскохозяйственных культур. - М.: Колос, 2001.-191 с.
5. Кагаловский С.П. Сортирование посевных семян хлопчатника // Хлопководства.- 1998.-№11.-11.-С.37-39.
6. Росабоев А.Т., Худоёров Ш.Т. Қишлоқ хўжалик экинлари уруғини тозалайдиган қурилма // Фан-техника, таълим, технологиялар: Долзарб муаммолар ва ривожланиш тенденциялари/Республика илмий-амалий анжумани материаллари. 2-қисм. – Жиззах, 2017. – Б. 393-394.

7. Mamadzhanov, B., Shukuraliev, A., Mannobboev, S., Turaev, S., Patidinov, A., & Mavlyanova, S. (2024). Dielectric separation. In E3S Web of Conferences (Vol. 471, p. 02017). EDP Sciences.
8. Shukuraliyev A.Sh. Nuriddinov N.A. Investigation of open-channel optrons for the control of metal surfaces qualitative parameters / Scientific research of the countries synergy and integration. – Pekin, 2018. – Pp. 68–72.
9. Росабоев А.Т., Шайимова С.П. Электр саралагич курилмаларининг технологик самарадорлигини ошириш йўллари//Фан-техника, таълим, технологиялар: Долзарб муаммолар ва ривожланиш тенденциялари/Республика илмий-амалий анжумани материаллари. 2-қисм. – Жиззах, 2017. – Б. 285-288.
10. Zakrullayevna Z. I. et al. ELECTRIC DOWNLOAD DIAGRAMS AND SELECTION OF ELECTRIC ENGINE POWER //European International Journal of Multidisciplinary Research and Management Studies. – 2022. – Т. 2. – №. 04. – С. 33-37.
11. Mamadzhanov B. D., ugli Mannobboev S. S. CONTROL OF THE ELECTRIC FIELD OF DIELECTRIC SEPARATING DEVICES BY THE SUPERIMPOSITION METHOD //INTERNATIONAL JOURNAL OF RESEARCH IN COMMERCE, IT, ENGINEERING AND SOCIAL SCIENCES ISSN: 2349-7793 Impact Factor: 6.876. – 2022. – Т. 16. – №. 07. – С. 37-41.
12. Мамаджанов Б. Д., Шукуралиев А. Ш., Манноббоев Ш. С. МЕТОДИКА РАСЧЕТА ЭЛЕКТРИЧЕСКОЙ ЕМКОСТИ РАБОЧЕГО ОРГАНА ДИЭЛЕКТРИЧЕСКОЙ СОРТИРОВОЧНОЙ МАШИНЫ //Educational Research in Universal Sciences. – 2023. – Т. 2. – №. 15. – С. 581-589.
13. Мамаджанов Б. Д., Манноббоев Ш. МЕРЫ ПО МИНИМИЗАЦИИ ПОТЕРЬ МОЩНОСТИ И ЭНЕРГИИ В ЭЛЕКТРИЧЕСКИХ СЕТЯХ //Educational Research in Universal Sciences. – 2023. – Т. 2. – №. 15. – С. 162-168.
14. Mamadzhanov B. et al. Dielectric separation //E3S Web of Conferences. – EDP Sciences, 2024. – Т. 471. – С. 02017.
15. Faye F. R. et al. The impacts of improper curbside parking on traffic flow in semi-urban area, Ethiopia //E3S Web of Conferences. – EDP Sciences, 2023. – Т. 434. – С. 02001.
16. Rage F. et al. Modelling and analysis of vehicle accident under mixed traffic conditions in Ilu Ababor zone, Ethiopia //E3S Web of Conferences. – EDP Sciences, 2023. – Т. 377. – С. 02002.
17. Mamadzhanov B. et al. Dielectric separation //E3S Web of Conferences. – EDP Sciences, 2024. – Т. 471. – С. 02017.