Formulation Of The Differential Equation Of Motion For Determining The Micronaire Index Of Cotton Fibers In The Universal Device

Mannopov B.A.
Head of Laboratory Scientific-Research Institute of Fiber Crops, Uzbekistan

Mannopov Bexzod Abdumalikovich
Head of Laboratory Scientific-Research Institute of Fiber Crops, Uzbekistan

Received: 12 Mar 2026 | Received Revised Version: 11 Apr 2026 | Accepted: 23 Apr 2026 | Published: 19 May 2026

Volume 08 Issue 05 2026 | Crossref DOI: 10.37547/tajabe/Volume08Issue05-04

Abstract

In this article, the issue of creating a differential equation of fiber movement in determining the microneural index of cotton fibers using a universal tool is considered. In the study, the effects of electrostatic force, gravity and acoustic pressure affecting the movement of cotton fibers in the acoustic chamber were theoretically analyzed. Differential equations representing the movement of fibers were created, and based on their solutions, the laws of vertical movement of fibers were determined. Also, the effect of acoustic impact of different frequencies on fibers on their movement, amplitude and energy was analyzed through graphs. The obtained results allow to increase the efficiency of using the acoustic method in determining the microneural index of cotton fiber and to improve the fiber sorting process.

Keywords: Efficiency, frequency, differential equation, electrostatistical force, research, amplitude, energy.

Cite This Article: Mannopov B.A., & Mannopov Bexzod Abdumalikovich. (2026). Formulation Of The Differential Equation Of Motion For Determining The Micronaire Index Of Cotton Fibers In The Universal Device. The American Journal of Agriculture and Biomedical Engineering, 8(05), 15–20. https://doi.org/10.37547/tajabe/Volume08Issue05-04

1. Introduction

The results of the study are of great importance in improving the process of determining cotton fiber quality parameters using universal devices, more accurately assessing the microneural index, and increasing the efficiency of fiber sorting. As a result of graphical analysis, it was found that with an increase in the frequency applied to the fibers, their speed of movement increases and their time of movement in the chamber decreases. Also, a small sound absorption coefficient ensures less attenuation of acoustic wave energy, increasing the efficiency of determining the microneural index.

$$m \cdot \frac{d\vartheta}{dt} = F - mg \tag{1}$$

Here: m - fiber mass; g - acceleration of free fall; $F=\frac{q_1\cdot q_2}{4\cdot\pi\cdot\varepsilon_0\cdot r^2}$ - electrostatic force; q_1 q_2 - charged fibers in the polarized field; ε_0 - electric constant; r - the distance of passing the fibers.

$$m\cdot\frac{d\vartheta}{dt}=\frac{q_1\cdot q_2}{4\cdot\pi\cdot\varepsilon_0\cdot r^2}-mg \tag{2}$$

$$\vartheta=(\frac{q_1\cdot q_2}{4\cdot\pi\cdot m\cdot\varepsilon_0\cdot\rho^2}-g)\cdot t+C_1 \tag{3}$$

(3) we determine the C_1--integral constant in the equation using the initial condition; $t=0$; $\vartheta=\vartheta_0$; from this $C_1=\vartheta_0$

$$\vartheta=(\frac{q_1\cdot q_2}{4\cdot\pi\cdot m\cdot\varepsilon_0\cdot r^2}-g)\cdot t+\vartheta_0 \tag{4}$$

$\vartheta=\frac{dx}{dt}$ we determine the movement of cotton fibers in the chamber by integrating equation (4).

$$\frac{dx}{dt}=(\frac{q_1\cdot q_2}{4\cdot\pi\cdot m\cdot\varepsilon_0\cdot r^2}-g)\cdot t+\vartheta_0$$

$$x=(\frac{q_1\cdot q_2}{4\cdot\pi\cdot m\cdot\varepsilon_0\cdot r^2}-g)\cdot\frac{t^2}{2}+\vartheta_0\cdot t+C_2 \tag{5}$$

(5) we determine the C_2-integral constant in the equation using the initial condition; $t=0$; $x=0$ we put the $C_2=0$ value determined from this into equation (5).

$$x=(\frac{q_1\cdot q_2}{4\cdot\pi\cdot m\cdot\varepsilon_0\cdot r^2}-g)\cdot\frac{t^2}{2}+\vartheta_0\cdot t \tag{6}$$

The equation of movement of cotton fibers in a vertical position in a universal device is defined. The analysis of the movement of cotton fibers under the influence of electrostatic force and sound speed is presented. In this case, by giving different frequencies to the cotton fibers, the microneural indicator of the fibers can be expressed by their movement.

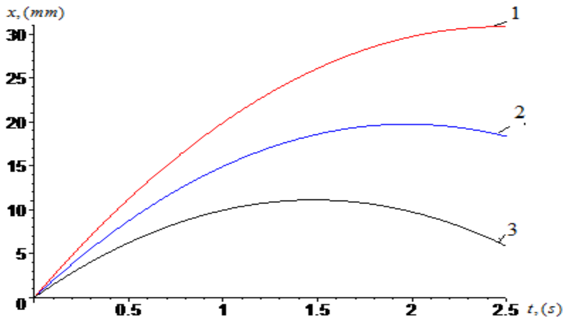

Figure 1. A graph of the vertical movement of the cotton fibers inside the chamber at different frequencies over time

We construct the differential equation of motion of cotton fibers passing through an $P(x,t)$ acoustic chamber, for which the following equation is relevant for the acoustic pressure.

$$\frac{\partial^2 P}{\partial t^2} = c^2 \cdot \frac{\partial^2 P}{\partial x^2} \tag{7}$$

Here: $P(x,t)$ -acoustic pressure; c - the speed of sound passing through the acoustic chamber, the pressure of the cotton fibers changes in coordinate and time, we determine using the following equation.

$$P(x,t) = X(x) \cdot t(t) \tag{8}$$

From equation (7) we get special derivatives based on expression (8).

$\frac{\partial^2 P}{\partial t^2} = X(x) \cdot \ddot{t}(t)$; $\frac{\partial^2 P}{\partial x^2} = \ddot{X}(x) \cdot t(t)$ we calculate the differential equation by putting these determined values into equation (8) above.

$$X(x) \cdot \ddot{t}(t) = c^2 \cdot \ddot{X}(x) \cdot t(t) \tag{9}$$

(9) from the differential equation $\frac{\ddot{t}(t)}{t(t)} = -\lambda$ we simplify it by introducing notation.

$$\ddot{x} + \frac{\lambda}{c^2} \cdot x = 0 \tag{10}$$

(10) we seek the solution of the second-order inhomogeneous differential equation as follows.

$$x = C_1 \cdot \cos(\frac{\sqrt{\lambda}}{c}\tau) + C_2 \cdot \sin(\frac{\sqrt{\lambda}}{c}\tau) \tag{11}$$

The differential equation (11) defines the movement of fiber flow in time as follows

$$\ddot{t} + \lambda \cdot t = 0 \tag{12}$$

(12) we seek the solution of the second-order inhomogeneous differential equation as follows.

$$t = A \cdot \cos(\sqrt{\lambda}\tau) + B \cdot \sin(\sqrt{\lambda}\tau) \tag{13}$$

In this case, the general solution of the movement of cotton fibers in the acoustic chamber is expressed as follows.

$$P(x,t) = X(x) \cdot t(t)$$

$$P(x,t) = (C_1 \cdot \cos(\frac{\sqrt{\lambda}}{c}\tau) + C_2 \cdot \sin(\frac{\sqrt{\lambda}}{c}\tau)) \cdot (A \cdot \cos(\sqrt{\lambda}\tau) + B \cdot \sin(\sqrt{\lambda}\tau)) \tag{14}$$

(14) from equality $\frac{\sqrt{\lambda}}{c} = k$ $\sqrt{\lambda} = \omega$ let make it look simple by adding a mark.

$$P(x,t) = (C_1 \cdot \cos(k\tau) + C_2 \cdot \sin(k\tau)) \cdot (A \cdot \cos(\omega\tau) + B \cdot \sin(\omega\tau)) \tag{15}$$

We determine $C_1\ ; C_2;\ A;\ B$ the integral constants in equation (15) using the initial condition. $P(x,0), \frac{\partial P}{\partial t}(x,0)$ $P(0,t), P(L,t)$ from the conditions $P_0 = f(C_1\ ; C_2;\ A;\ B)$ - By simplifying the combining the constants into one amplitude and phase, we determine the pressure change of the fibers in the acoustic chamber.

$$P(x,t) = P_0 \cdot \cos((k - \omega) \cdot \tau + \varphi) \tag{16}$$

Using equation (16), the pressure change during the sorting of the fibers passing through the chamber is analyzed graphically using the Maple program.

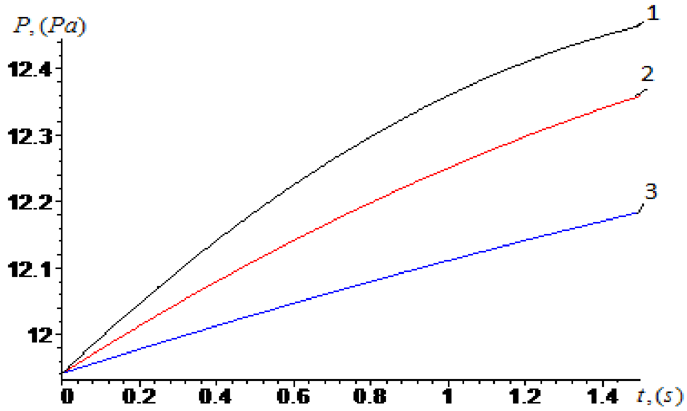

Figure 2. Graph of the change in pressure exerted on cotton fibers inside the chamber at different frequencies over time

We determine the amplitude and intensity of the cotton fibers moving along the OX axis as they pass through the chamber.

$$A = A_0 \cdot e^{-\gamma \cdot x})$$

$$I = I_0 \cdot e^{-2 \cdot \gamma \cdot x}$$

(17) We determine the $\gamma -$ sound absorption coefficient in the expression (17) as follows.

$$\gamma = \alpha + \beta \cdot i \qquad (18)$$

α - attenuation of sound vibrations; β - number of waves.

If the fibrous mass layer is taken from equation (18) as x=L, then the amplitude of the sound wave is determined as follows.

$$A = A_0 \cdot e^{-\gamma \cdot L} \qquad (19)$$

We determine the dependence of the attenuation of acoustic vibrations on the parameters of the fibers in the field of low-frequency sound vibrations transmitted to the fiber stream transmitted to the chamber as follows.

$$\alpha = \frac{1-\varepsilon}{\varepsilon} \cdot R \cdot S_0 \cdot \sqrt{f} \qquad (20)$$

έ- fiber porosity; f -sound vibration frequency; S_0 -fiber relative surface area;

R-constant coefficient Using equations (18) and (19), we determine the amplitude and intensity in equation (20) as follows:

$$A = A_0 \cdot e^{-\left(\frac{1-\varepsilon}{\varepsilon}\cdot R\cdot S_0\cdot\sqrt{f}+\beta\cdot i\right)\cdot L}$$
$$I = I_0 \cdot e^{-2\cdot\left(\frac{1-\varepsilon}{\varepsilon}\cdot R\cdot S_0\cdot\sqrt{f}+\beta\cdot i\right)\cdot L} \qquad (21)$$

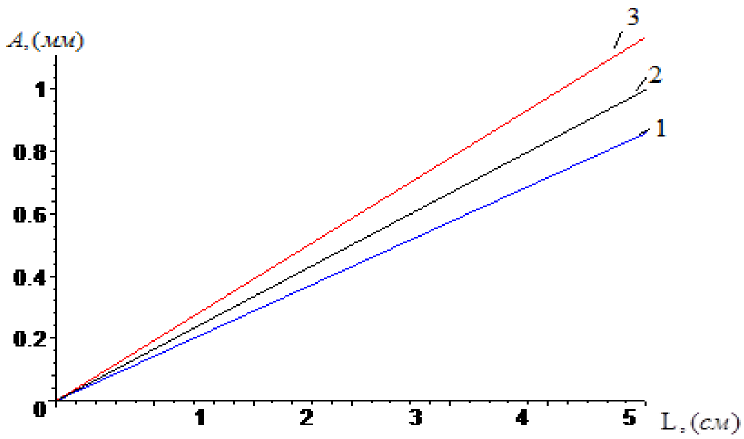

Figure 3. Graph of the amplitude change in the chamber length under the influence of different frequencies applied to cotton fibers inside the chamber

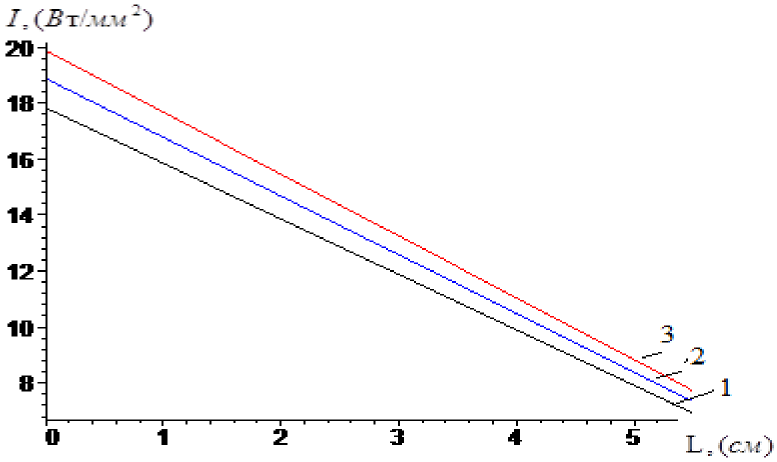

Figure 4. Graph of changes in energy at different frequency values applied to the cotton fibers inside the chamber over the length of the chamber

As a result of theoretical studies, a differential equation of fiber motion was constructed and its solutions were analyzed when determining the microneural index of cotton fibers in a universal device. Studies have shown that the motion of cotton fibers inside an acoustic chamber is affected by electrostatic force, gravity, and acoustic pressure. The mathematical model, which takes these factors into account, allows for a more accurate description of fiber motion.

From the above graphs 3-4, it can be seen that when determining the microneural index of fibers, the smaller the sound absorption coefficient, i.e., the less sound attenuation, the less energy is absorbed, which in turn increases the effectiveness of determining the microneural index of fibers.

Conclusion

From the analysis of the above graph, it should be noted that the microneural index of cotton fibers, which cover the shortest and fastest distance at the highest frequency, is indicated, and on this basis, it is possible to determine their efficiency depending on the frequency. Thus, the graph shows that cotton fibers cover the fastest distance in the shortest time at the value of the frequency of movement in a vertical state.

References

1. Rashidov T.R., Shoziyotov Sh., Muminov K.B. Fundamentals of Theoretical Mechanics. – Tashkent.: Ukituvchi, 1990.
2. Shohaidarova P., Shoziyotov Sh., Zoirov J. Theoretical Mechanics. Tashkent.: Teacher, 1991.
3. Piskunov N.S. Differential and integral work., Moscow: Nauka. 1976.
4. Piskunov N.S. Differential and integral work., Moscow: Nauka. 1970.
5. Miroshnichenko G.I. Basic design machine primary processing cotton. Moscow: Mashinostroeniya.
6. Yoldoshev Q.P. Methodical guide to the performance of coursework in theoretical mechanics. -Tashkent: "Uzbekistan".