UDC 677.024.017

METHOD FOR MEASURING WOOL FIBER DIAMETER

МЕТОД ОПРЕДЕЛЕНИЯ ДИАМЕТРА ШЕРСТЯНОГО ВОЛОКНА

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ABSTRACT

WOOL, LENGTH, DIAMETER, UNEVENNESS, ACOUSTIC DEVICE

Woolen fiber is a very heterogeneous raw material. Therefore, accurate, correct, and rapid determination of the diameter of the wool fibers is an urgent task, predetermining the efficiency and profitability of the wool processing. The article analyzes the process of sound oscillations passing through the wool sample of the PAM-1 device enclosed in the measuring chamber, in order to verify the possibility of measuring the diameter of the wool fiber.

АННОТАЦИЯ

ВОЛОКНО, ШЕРСТЬ, ДЛИНА, ДИАМЕТР, НЕРОВНОТА, АКУСТИЧЕСКИЙ ПРИБОР

Шерстяное волокно является весьма неоднородным сырьём. Поэтому точное, правильное, быстрое определение диаметра шерстяных волокон является актуальной задачей, предопределяющей эффективность и прибыльность шерстеперерабатывающего производства. В статье проанализирован процесс прохождения звуковых колебаний через пробу шерсти, заключенной в измерительную камеру прибора ПАМ-1, для возможности проверки возможности измерения диаметра шерстяного волокна.

The diameter of wool largely determines the technology of its processing into yarn and plays a decisive role at all stages of production and processing to finished products. Cross section of wool is the basis of the scientific and technical classification of wool, and the study of the peculiarities of its formation and connections with other features of sheep determines the current possibilities of using new scientifically sound methods of selection and use of wool in the processing industry in the wool economy. It is also important that the diameter of the wool plays the role of a pricing factor, and, therefore, affects the profitability of the sheep industry as a whole.

To check the possibility of measuring the diameter of the wool fiber, we analyze the process of the passage of sound vibrations through a sample of wool enclosed in the measuring chamber of the device PAM-1. When plane sound waves pass through a fiber sample, energy losses occur due to friction against the fiber surface, which leads to a change in the amplitude of sound vibrations and a phase shift of sound waves. The amplitude of a plane sound wave along the OX axis, which coincides with the direction of wave propagation, varies according to the formula:

$$P = P_0 e^{-jl}, \quad (1)$$

where P_0 – is the pressure of sound vibrations before the breakdown of the fiber;

l – is the thickness of the fiber sample layer;

j – is the propagation constant, determined by the formula:

$$j = \alpha + \beta i, \quad (2)$$

where α – sound attenuation coefficient;

β – wave number.

After determining the optimal parameters of the wool fiber for measurement on the PAM-1 device, the principle of measuring the attenuation of sound fibers is considered.

Therefore, the relationship of the output signal in the low-frequency region of sound vibrations shows the dependence of the attenuation of acoustic vibrations on fiber parameters

$$\sigma = \frac{1-\varepsilon}{\varepsilon} k S_O \sqrt{f}, \quad (3)$$

where ε – porosity of the fiber sample equal to the ratio of the pore volume in the sample to the total sample volume;

f – frequency of sound vibrations; Hz

S_0 – specific fiber surface equal to the ratio of the lateral surface area of the fibers in the sample to their volume, 1/m

k – constant coefficient.

In this work, we study the dependence of the fineness of a wool fiber on the attenuation of sound vibrations.

For this purpose, we derive the functional relationship of the damping coefficient of sound vibrations α with the diameter of the wool fiber.

Woolen fiber has a cylindrical shape. Therefore, the specific surface of the wool fiber is determined from the following relationship;

The specific surface of the wool fiber is determined by the expression

$$S_0 = S_B / V_B, \quad (4)$$

where, S_B – the area of the side surface of the wool fiber;

V_B – fiber volume is determined by the following expressions

$$S_B = \pi \cdot d \cdot l, \quad (5)$$

$$V_B = \frac{\pi \cdot d^2}{4} \cdot l \quad (6)$$

where d – diameter of fiber; mm:

l – fiber length, mm.

By substituting the expressions (5) and (6) in (4) after simple transformations, we obtain the following expression for the specific surface area of wool

$$S_o = 4 / d, \quad (7)$$

By substituting the expression (8) in (4) we obtain the following ratio for attenuation factor

$$\alpha = \frac{4(1-\varepsilon)}{\varepsilon \cdot d} k \sqrt{\int}, \quad (8)$$

having designated

$$B = \frac{4k(1-\varepsilon)}{\varepsilon} \sqrt{f}, \quad (9)$$

let's receive

$$\alpha = \beta / d, \tag{10}$$

By replacing in formula (1) the sound vibration pressure on the device output signal proportional to it, we have the following expression

$$U = U_0 e^{-al}, \tag{11}$$

By substituting in formula (11) the expression (10) for the attenuation factor and prologarithm the resulting expression

$$LnU = LnU_0 - \frac{B \cdot l}{d}, \tag{12}$$

Given the assumptions taken in the inference of formula (9), it can be assumed that there must be a linear regression between the logarithm of the output of the instrument and the diameter of the wool fiber.

$$LnU = A_0 - \frac{A_1}{d}, \tag{13}$$

here $A_o = LnUo$, $A_1 = Bl$.

Based on the results of the experiment planning, the following conclusions can be drawn:

- the sound impulse of the samples increases with increasing diameter, mass and humidity in the selected ranges of variation;

- comparison of regression coefficients with the corresponding factors shows that the greatest influence in the conducted experiments is the diameter of the woolen fiber.

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