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Study on the process automatization of wetting (moistening) the seeds using a step motor

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Abstract. Researcher Urishev was the first to deal with the issues of mechanization of the process of moistening cotton seeds in the Republic of Uzbekistan. He also developed many devices and mechanisms and proposed methods for conducting experiments on moistening pubescent cotton seeds. However, his works did not address the issues of automation of laboratory facilities. And also Urishev used chemicals for seed treatment, which is harmful to humans and the environment. The creation of an environmentally friendly technology for pre-sowing disinfection of cotton seeds is an urgent task for cotton growing. Research in this field of science has led to the use of electrical energy as the most harmless and cheap means. Along with researchers studying electrical technology in the Republic of Uzbekistan, under the guidance of Professor Mukhammadiev, research work has been carried out since 1985: to develop a non-chemical technology for growing cotton using a spark discharge current, an alternating electric current of industrial frequency. In this article, the possibilities of automating the process of lifting and lowering a laboratory test mechanism for studying the friction of dry and moist cotton seeds proposed by Urishev with the help of a stepper motor were studied in order to automate the process of laboratory experiments. We also obtained equations for finding the resulting force.

1. Introduction

It is known that grain moisture is a factor that reflects the amount of nutrients and the possible duration of storage of the grain mass. It is one of the key quality indicators and is determined immediately after the acceptance of a new batch of culture [1].

According to the author the best result of an increase in germination by 1.5% was obtained at 60 s and 1.17 kW/kg. When treating seeds, it is recommended to maintain an average microwave heating rate of 0.50 °C/s until an average microwave heating temperature of 51.5 °C is reached [2].

According to the authors [3, 4, 5] in the article the most effective condition of presowing processing of seeds in magnetic field is 0.065 T magnetic induction with four times magnetic reversal and 0.4 m/s seed velocity.

It is known that the researcher Urishev [6] did a lot of practical work, obtained such scientific results as seed wetting, determination of friction coefficients on various surfaces. It is very important to carry out experimental work that requires accurate measurements. This is the purpose of this article. We studied in detail the work of the researcher [6] and obtained the prerequisites for the possibility of using a stepper motor to improve the measurement accuracy. In particular, technical solutions have been proposed to calculate the forces that affect the friction between the seed and the metal surface. The issues of using the Arduino complex to control a stepper motor were also studied.

2. Materials and Methods

According to Urishev [6], swollen and non-swollen seeds have different angles of repose, which is significantly higher for non-swollen seeds of manual moistening than for seeds moistened by mechanized method. This is due to the following reasons. In non-swollen seeds of manual moistening, water does not completely penetrate into the down, and this causes molecular bonding forces between the seeds. When the seeds swell, this water is absorbed by the skin and the kernel of the seed, and the molecular bonding forces disappear. With the mechanized method of moistening, the supplied water rate is completely absorbed by the seed undercoat and penetrates into it, and this helps to reduce the angle of repose, i.e. increase the flowability of pubescent seeds [6].

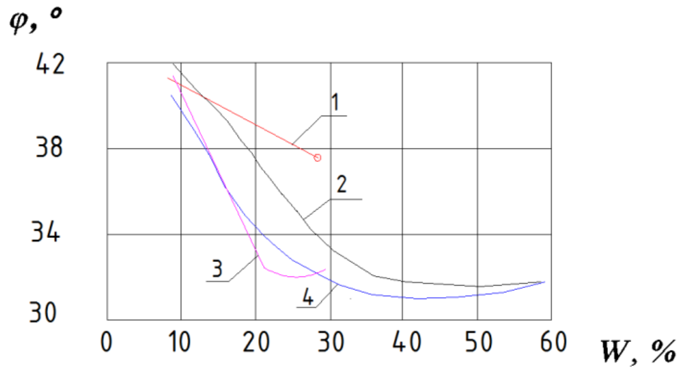

Figure 1. Dependence of the angle of repose φ of seeds on their moisture content W and the method of wetting: 1,3 - unswollen seeds moistened by manual and mechanized methods, 2,4 - swollen seeds, moistened by manual and mechanized methods [6]

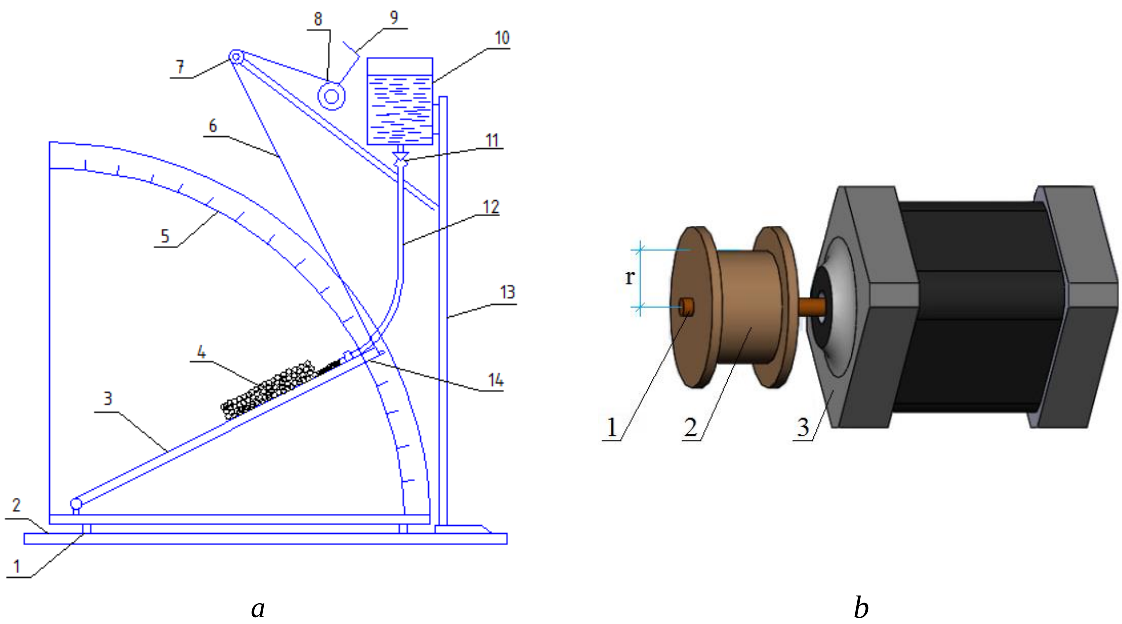

Figure 2. To the method for determining the coefficient of static friction: a - is the initial scheme(1-adjusting screw; 2-base; 3-working surface; 4-seeds; 5-scale; 6-rope; 7-roller; 8-drum with clutch and step motor; 9-handle; 10-barrel for water; 11-faucet; 12-flexible pipe; 13-stand; 14-tip.); b - rotating mechanism (1- shaft; 2- drum with clutch; 3- step motor)

According to the Figure 1, it can be seen that humidity and the method of moistening have a significant impact on the angle of repose of cotton seeds. And with an increase in the moisture content of (swollen)

seeds up to 47% with both methods of moistening (curves 2,4 in Figure 1), the angle of repose decreases intensively and changes slightly with a further increase [6].
The dormant friction coefficient of seeds of different moisture content on a dry, wet and wet surface began to be determined on an "inclined plane" device (Figure 2, right figure). To create a wet surface, the plane (steel) was wiped with a damp cotton material before each experiment, and then the test seed sample was placed. When studying the coefficient of friction of seeds on a wet surface, G. Urishev began [6] to equip the inclined plane with a sprayer, a container with water and a tap (Figure 2, left figure) connected to the sprayer with a hose.
Before installing the test seed sample, the container valve was opened and spread over the friction surface, forming a liquid lubricating the seed sample of a certain moisture content, and the friction surface of the device discs was cleaned with acetone after each experiment.
The friction surface was dry and wet, as when cotton seeds are moistened, they come into contact with such surfaces. Wet material is installed on the device to moisten the friction surface. The effect of specific pressure on the coefficient of friction was determined at a sliding speed of 1.0 m/s corresponding to the average peripheral speed of the mixing drum of the humidifier. The required specific pressure on the mass of seeds was created using a plate and weights inside a cubic box.

3. Results and Discussions

Analysis of the change in the coefficient of sliding friction of seeds on specific pressure (Figure 3) showed that with an increase in specific pressure, the coefficient of sliding friction decreases and has different values for different seed moisture and surface conditions. This is explained by the fact that with an increase in the specific pressure, the loose part (seed wool) of the seed sticks to the surface of the seed coat, which helps to reduce the adhesion force of the seed coat to the friction surface.
Dry seeds on a wet surface have the highest sliding friction coefficient, while dry seeds on a dry surface have the lowest values.
The influence of the sliding speed on the coefficient of friction was determined at a specific pressure of 60 Pa, since it corresponds to the average value of the pressure acting on the working surfaces of the mixing drum.

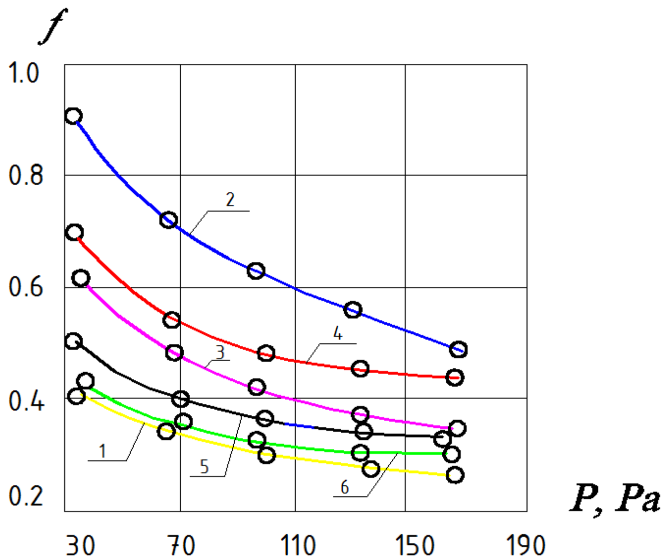

Figure 3. Coefficient of sliding friction of cotton seeds f depending on the specific pressure P: 1-dry seeds on a dry surface; 2- dry seeds on a wet surface; 3,4,5,6 - seed moisture, respectively, 30,50,70, and 90%

The results of the study of the friction coefficient of seeds depending on the sliding speed (Figure 4) show that with an increase in speed from 0.8 to 1.4 m/s, the coefficient of sliding friction decreases for seeds with moisture: 8.2% from 0.5 to 0.37; 30% from 0.70 to 0.55; 50% from 0.76 to 0.60; 70% from 0.60 to 0.40 and 90% from 0.56 to 0.50.

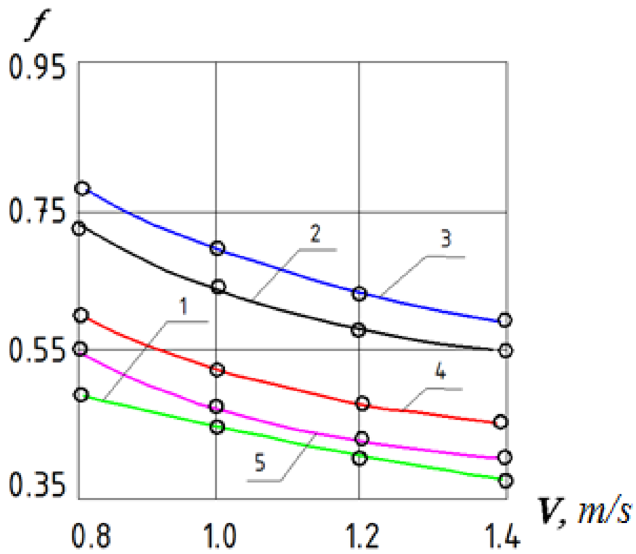

Figure 4. Effect of seed sliding speed ***V*** on the kinetic friction coefficient ***f***: 1-dry seeds on a dry friction surface; 2,3,4,5-moistened seeds with 30,50,70 and 90% moisture content

The effect of cotton seed moisture on the coefficient of friction was studied at a specific pressure of 60 Pa and a sliding speed of 1.0 m/s.

The researchers proposed a parametric block diagram of the electrical technology of seed treatment and an electronic model for the pubescent cotton seed [7, 8].

Seed treatment efficiency depends on the dose being determined by the parameters of electric field, namely, intensity in the seed layer, pulse duration, pulse repetition frequency, and seed treatment time [9, 10].

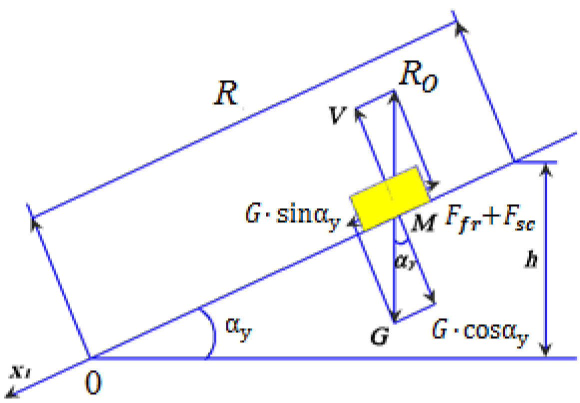

Figure 5. Model of seed movement on the surface of the inclined wall of the equipment

The slope angle of the working surface is inversely proportional to the length of the base *R* (friction surface length), proportional the radius of the drum with clutch r and the number of revolutions of the step motor *n*. The calculation expressions are detailed below.

Circumference of drum with clutch (Eq. 1):

$$l = 2\pi r \tag{1}$$

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l is the length of the arc formed by the angle a_y (Eq. 2):

$$l_{circle\ arc} = \frac{Ra_y\pi}{180} \tag{2}$$

We equate expressions (1) and (2)

$$l_{circle\ arc} = n \cdot l$$

and we get the following formula (Eq. 3 and 4):

$$\frac{Ra_y\pi}{180} = n \cdot 2\pi r \tag{3}$$

$$a_y = \frac{360rn}{R} \tag{4}$$

The following forces act on the seeds located in the inclined plane of the device: gravity force $\boldsymbol{G}$, friction force F_{fr}, adhesion force of seeds to each other with their pads F_{sc} and normal reaction force $\boldsymbol{N}$.
For the movement of seeds from top to bottom along the surface of an inclined plane (Figure 5), and the following condition must be satisfied (Eq. 5):

$$G \cdot \sin\alpha_y = F_{fr} + F_{sc} \tag{5}$$

Friction and adhesion forces are determined by the following expressions (Eq. 6 and 7):

$$F_{fr} = f_y \cdot N = f_y \cdot \mathrm{G} \cdot \cos\alpha_y = f_y \cdot (m_s + m_w)\mathrm{g} \cdot \cos\alpha_y = \\ = 0.58 \cdot (1.00 + 0.25) \cdot 9.81 \cdot cos25° = 6.4\ \mathrm{N} \tag{6}$$

$$F_{sc} = j_y \cdot N = j_y \cdot \mathrm{G} \cdot \cos\alpha_y = j_y \cdot (m_s + m_w)\mathrm{g} \cdot \cos\alpha_y = \\ = 0.58 \cdot (1.00 + 0.25) \cdot 9.81 \cdot cos25° = 6.4\ \mathrm{N} \tag{7}$$

here f_y and j_y – friction and adhesion coefficients, respectively for seeds cotton 0.58 [6];
a_y – the angle of inclination of the inclined plane relative to the horizon, degrees;
m_s – mass of seed, kg,
m_w - mass of water, kg.
A downward x_1 coordinate axis is drawn along the inclined surface of the equipment, the motion begins at point $\boldsymbol{M}$ down the x_1 axis, and the seed is considered a material point. The initial conditions for the movement of the seed down the x_1 axis in the inclined surface plane are assumed to be: $x_1 = 0$ at $t = 0$.
The movement of the seed along the x_1 axis in the inclined plane is represented by the following differential equation (Eq. 8):

$$m_y \cdot \frac{d^2X_1}{dt^2} = G \cdot \sin\alpha_y - F_{fr} - F_{sc} \tag{8}$$

In this case, the length of the inclined plane of the equipment x_1 =35 cm, the acceleration of free fall $g = 9.81\ m/s^2$, the angle of inclination $a_y = 30° - 90°$, the coefficients of friction of the seeds on the metal surface and their adhesion, $f_y = j_y = 0.15 \div 0.35$ was taken as. According to the calculation result of expression (8) above, the stepper motor torque was determined and a stepper motor suitable for the experimental device was installed.
A hybrid stepper motor is a brushless DC electric motor that moves in precise angles, called steps, by converting a series of electrical pulses into rotational motion. They will not produce continuous motion from a continuous input voltage, and it will stay at a particular position as long as the power is “on”. Hybrid step motors are controlled with the use of discrete electrical pulse signals. Each pulse will rotate the step motor shaft by a fixed angle called a “step”. Lin Engineering hybrid stepper motors have several different step angles to choose from (0.45°, 0.9°, 1.8°).

4. Conclusions

The prerequisites have been created for automating the process of wetting (moistening) of seeds using a step motor. The mathematical and physical modeling of fragments of moistening of a flat plate and cotton seeds is discussed. In particular, a model was created that replaces a manual rotating mechanism with an intelligent system using a stepper motor (step motor) to determine the friction coefficient of cotton seed moistened with various water compositions. Illustrative materials are presented, modern methods of calculation and modeling using computer programs are studied and applied. The necessary conditions for the detection of calculation errors were created, as well as a database in the area of research under consideration.

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