Innovative Development in Educational Activities ISSN: 2181-3523 VOLUME 2 | ISSUE 6 | 2023
Scientific Journal Impact Factor (SJIF): 5.938 http://sjifactor.com/passport.php?id=22323

CREATING A MATHEMATICAL MODEL OF THE CLEANING PROCESS OF COTTON RAW MATERIALS UNDER THE INFLUENCE OF AIRFLOW

Nurbek Nuritdinov [a], Islomjon Makhamadjanov [b],
Muhammadyusuf Gofurjonov, Musokhon Urmonov
Namangan Engineering-Construction Institute, Namangan, Uzbekistan

[a] *Corresponding author: nuritdinovnurbek85@gmail.com*
[b] *islomiy1101@gmail.com*

Abstract. *This research work is aimed at obtaining quality fiber during the operation of the ginnery, in which the software is developed to determine the optimal parameters of the required device, on the basis of which the parametric values are determined by conducting a computational experiment.*
Keywords: *cotton raw material, fiber separation shop, technological process, separator, cotton cleaning device, mesh surface, perpendicular, mathematical model, oscillating mesh surface, differential equations, Runge-Kutta methods, Matlab.*

INTRODUCTION

In the following years, the state developed a strategy and development program for the cotton-growing sector of the Republic of Uzbekistan. In order to ensure the implementation of the program in practice, it is shown that, in addition to increasing the productivity of cotton, it is necessary to pay more attention to the preliminary processing of its raw materials. is also shown [1]. According to experts, the consumption of cotton fiber in Uzbekistan is expected to increase in the near future. Within the framework of the concept of development of the cotton growing sector of the Republic of Uzbekistan and the development of dozens of investment projects, it is expected to increase the level of cotton fiber processing to 80% of the total production volume and increase the export potential of the Uzbek industry by more than 3 times, these actions are the future-oriented economic policy of the republic [2].

In the process of carrying out the research practice in cotton ginning factories in the conditions of Uzbekistan, including in the cotton ginning factory of Kosonsoy district of Namangan region, the following stages of work were observed: cotton raw materials are dried in drying drums (2 SB-10); dried cotton raw materials are cleaned of coarse and fine impurities using the UXK cleaning line; cleaned cotton raw materials

- separates the fiber from the seed on 5 DP-130 (jin) equipment in the fiber separation shop; the obtained fiber is spun in the press shop on DB-8237 press equipment; the woven fiber is weighed on electronic scales and transferred to the finished product warehouse using a belt conveyor. In LP-type linter aggregates, lint is separated from the seed, and the lint is pressed in DA-237 press equipment; the fluff is weighed on an electronic scale and transferred to the finished product warehouse. The seed product is weighed on an electronic scale and moved to the seed warehouse through elevators and augers [3, 4].

It is known that the organization of the correct technological process is of particular importance in order to obtain a quality product from seed cotton in cotton ginning enterprises. If the technological process of the enterprise is organized correctly, then the quality of the obtained product will be good, the cost and costs of production will decrease, and the enterprise will see good profit and development.

In addition to studying the sources mentioned above, in our research we paid attention to the fact that the large impurities in cotton are less included in the cotton raw materials, but the small impurities are deeply embedded in the cotton raw materials. The removal and separation of such small impurities from the cotton content, in turn, requires complex vibration and horizontal and vertical vibration. For this, it is necessary to develop a new device with an inclined vibrating mesh surface.

a) b) c) d)

FIGURE 1. Cases of seed cotton.

This oscillating mesh surface cotton cleaning device was developed by us, and the picture showing its working process is shown below (see figure 2).

In this device, cotton is cleaned using a completely new technology - a separator (this method is based on the passage of seeded cotton through successive mesh surfaces). In order to get rid of impurities during the separation process, the maximum use of the mesh surface is provided, that is, the piece of cotton moving from the first mesh surface to the 2nd mesh surface first hits the protective surface (4) and changes its direction as a result of reflection.

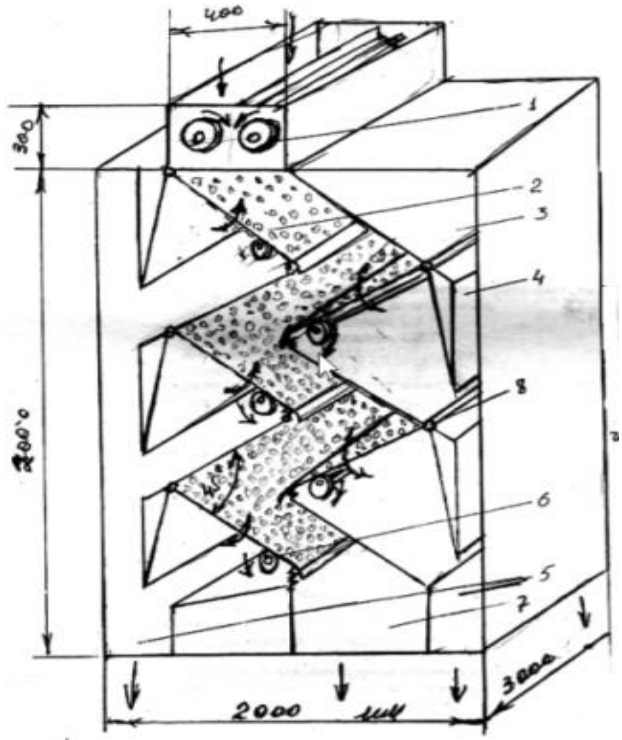
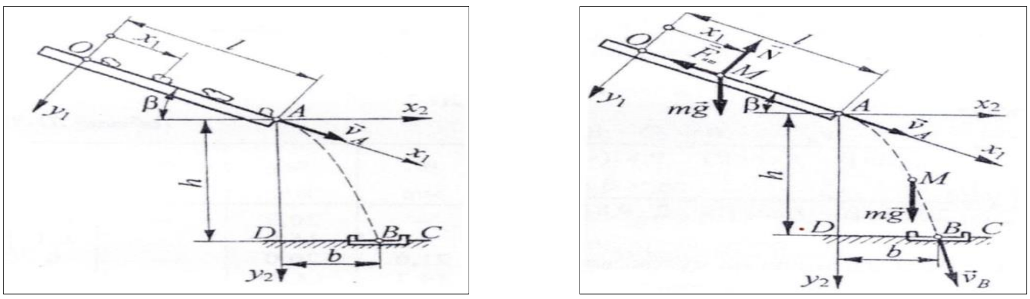


FIGURE 2. Cotton cleaning device: 1 - movement provider; 2 - mesh surface (in oscillating motion); 3 - protective and guiding surface; 4 - protective surface; 5 - impurity chamber; 6 - balls (ellipsoids move mesh surface); 7 - cleaned cotton drop chamber.

In the next process, the piece of cotton passes through the 3-4-5-6 mesh surfaces of the device, is collected in the cleaned cotton drop chamber (7), and is transferred to the required places. In the process of separation, the impurities contained in seeded cotton are expelled out of the device through a special chamber (5).

In order to develop a mathematical model of a piece of cotton moving along a straight line on the mesh surface of this device (4) during the research, we present the following drawing(see figure 3).



a) b)

FIGURE 3. Forces acting on a piece of cotton. a) To a piece of cotton moving along a straight line; b) To a piece of cotton moving along an inclined plane.

EXPERIMENTAL WORK

The part *OA* of the mesh surface of the cotton cleaning device consists of an inclined plane forming an angle β with the horizontal plane. Suppose a piece of cotton starts moving from a rest position (point *O*) on a mesh surface and leaves the mesh surface with speed v_A at point *A* (Fig. 3a).

The sliding friction coefficient of the mesh surface is equal to *f*. Considering the piece of cotton as a material point and not taking into account the air resistance, we determine the time taken by the piece of cotton from the beginning of its movement until it falls on the next mesh surface and the speed of impact v_B from a height *h*.

During the movement of a piece of cotton along an inclined plane *OA*, the following forces act on it: weight force $P=mg$, normal reaction force *N*, and sliding friction force $F_{friction}$ (Fig. 3b).

Three interrelated mechanisms can be seen in the study of a piece of cotton flow on a vibrating mesh surface:

1. At an angle of β (betta) degrees with respect to the horizon of the mesh surface, the piece of cotton flow on the mesh surface moves step by step (along the mesh surfaces in steps 1-2) and linear shift is observed (between points *OA-AV*);
2. The surface surfaces of the mesh surface (Fig. 2) are perpendicular to each other, and all the dust and dirt contained in the moving cotton stream pass through the holes of the mesh surface.
3. Due to the passage of impurities through the holes of the mesh surface, the cotton flow is cleaned of small impurities (small stones, sand, soil, and small leaf fragments), and the degree of porosity of the seeded cotton increases due to foaming, as a result, the quality of cotton cleaned from small impurities improves.

We express the technological process ($F\mu$) that occurred on the surface of the mesh surface, as an existing object of study, through the following functional relations.

$F\mu = f(\Omega T, \Omega I, \Omega X) = f[(\Omega T1, \Omega T2, \Omega T3, \ldots, \Omega Tn), (\Omega I1, \Omega I2, \Omega I3, \ldots, \Omega In), (\Omega X1, \Omega X2, \Omega X3, \ldots, \Omega Xn)]$

where: ΩT - external factors, ΩI – internal factors, ΩX - factors not taken into account.

METHOD

Matematik ifodani shakllantirishda mexanik qonun bo‘yicha to‘rli yuza sirtidagi paxta bo‘lagini garmonik tebranish jarayonini asos qilib olindi va uni quyidagi chizmada nisbiy hol uchun keltiramiz(2.4-rasm).

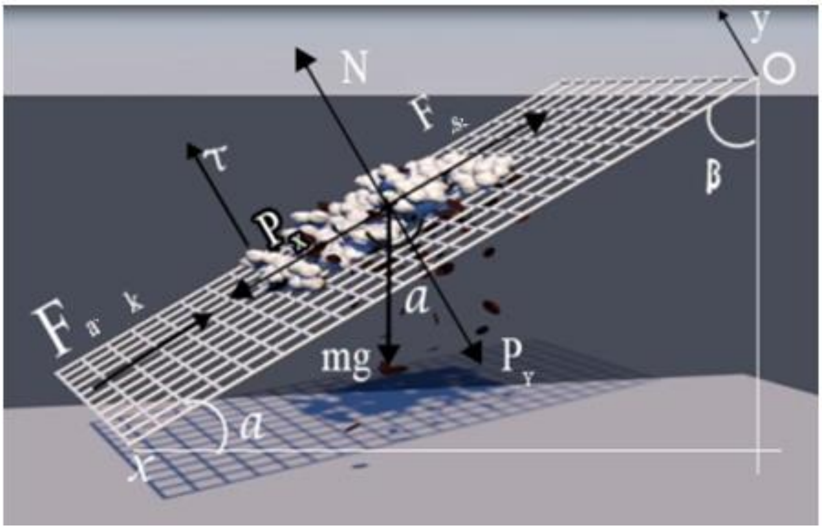


FIGURE 4. Harmonic motion of a piece of cotton on a mesh surface and the forces acting on it.

Let the piece of cotton move relative to the harmonic law (1) in the *OY* direction (Fig. 4).

$$\tau = A\sin\omega t \qquad (1)$$

That is, we consider that a piece of cotton moving on a mesh surface (1) is moving harmonically according to the law. In this case, the forces acting on the piece of cotton in the *OX* and *OY* directions are:

$$\left.\begin{aligned} X &= P\sin\alpha - F_{friction\_x} - F_{air\_k} \\ Y &= N - P\cos\alpha = A\sin\omega t + F_{air\_k} \end{aligned}\right\} \qquad (2)$$

where:

$P = mg$ - gravity;

$F_{friction\_x} = \mu_x N$ - frictional force acting on a piece of cotton;

F_{air_k} – air flow force;

F_x, F_y - Forces acting on a piece of cotton along the Ox and Oy axes, *N*;

N - normal compressive strength, *N*;

A - external force vibration amplitude, *cm*;

ω - number of oscillations, *Hz*.

Based on the relevant changes, we interpret the differential equation of motion of a piece of cotton as follows, i.e., taking $F_x = ma_x$ and $F_y = ma_y$ into account, we express it as follows:

$$\left.\begin{aligned} ma_x &= mg\sin\alpha - \mu_x N - F_{air\_k} \, (a) \\ ma_y &= N - mg\cos\alpha + F_{air\_k} \quad (b) \end{aligned}\right\} \qquad (3)$$

We divide both sides of expression (3) by m (mass).

$$\left.\begin{aligned} a_x &= g\sin\alpha - \frac{\mu_x}{m}N - \frac{1}{m}F_{air\_k} \quad (a) \\ a_y &= \frac{N}{m} - g\cos\alpha + \frac{1}{m}F_{air\_k} \quad (b) \end{aligned}\right\} \quad (4)$$

or,

$$\left.\begin{aligned} \frac{du}{dt} &= g\sin\alpha - \frac{\mu_x}{m}N - \frac{1}{m}F_{air\_k} \quad (a) \\ \frac{dw}{dt} &= \frac{N}{m} - g\cos\alpha + \frac{1}{m}F_{air\_k} \quad (b) \end{aligned}\right\} \quad (5)$$

Here u and w are the velocities of the piece of cotton in the axial and lunar directions, respectively. We determine N expressions from the law of motion in the OY direction:

$$m\frac{d^2\tau}{dt^2} = N - mg\cos\alpha + F_{air\_k} \;\Rightarrow\; N = mg\cos\alpha - mA\omega^2\sin\omega t + F_{air\_k} \quad (6)$$

We put expression (6) into (5) and get the following expression:

$$\left.\begin{aligned} \frac{du}{dt} &= g\sin\alpha - \mu_x g\cos\alpha - \mu_x A\omega^2\sin\omega t - \frac{\mu_x}{m}F_{air\_k} - \frac{1}{m}F_{air\_k} \quad (a) \\ \frac{dw}{dt} &= g\cos\alpha - A\omega^2\sin\omega t - \frac{1}{m}F_{air\_k} - \frac{g}{m}\cos\alpha + \frac{1}{2}F_{air\_k} \quad (b) \end{aligned}\right\} \quad (7)$$

We determine the speed expression by integrating the system of equations (7) 1 time:

$$\left.\begin{aligned} u &= tg\sin\alpha - t\mu_x g\cos\alpha + \frac{1}{2}A\mu_x\omega^3\cos(\omega t) - \frac{\mu_x}{m}F_{air\_k}t - \frac{1}{m}F_{air\_k}t \quad (a) \\ w &= tg\cos\alpha - A\omega^3\cos(\omega t) + \frac{1}{m}F_{air\_k}t - \frac{g}{m}\cos\alpha\, t + \frac{1}{m}F_{air\_k}t \quad (b) \end{aligned}\right\} \quad (8)$$

In particular, the method of mathematical expression of the movements that occurred while conducting observation work on the movement of a piece of cotton oscillating on the mesh surface of an inclined plane was considered above. Based on it, according to the laws of mechanics, we created a mathematical expression of the process of harmonic vibration of a piece of cotton on a mesh surface.

$$\left.\begin{aligned} \frac{du}{dt} &= g\sin\alpha - \mu_x g\cos\alpha - \mu_x A\omega^2\sin\omega t - \frac{\mu_x}{m}F_{air\_k} - \frac{1}{m}F_{air\_k} \quad (a) \\ \frac{dw}{dt} &= g\cos\alpha - A\omega^2\sin\omega t - \frac{1}{m}F_{air\_k} - \frac{g}{m}\cos\alpha + \frac{1}{2}F_{air\_k} \quad (b) \end{aligned}\right\} \quad (9)$$

Equation (a) of the system (9) is the expression of the speed of movement of a piece of cotton along the mesh surface

$$\left.\begin{aligned} u &= tg\sin\alpha - t\mu_x g\cos\alpha + \frac{1}{2}A\mu_x\omega^3\cos(\omega t) - \frac{\mu_x}{m}F_{air\_k}t - \frac{1}{m}F_{air\_k}t \quad (a) \\ w &= tg\cos\alpha - A\omega^3\cos(\omega t) + \frac{1}{m}F_{air\_k}t - \frac{g}{m}\cos\alpha\, t + \frac{1}{m}F_{air\_k}t \quad (b) \end{aligned}\right\} \quad (10)$$

A piece of cotton moves on an oscillating mesh surface based on equation (a) of the system (10). That is, it represents the movement of a piece of cotton over time. In the given equation, the initial condition (*x=0 at t=0*) is known.

Finding the exact solution of differential equations is possible only in rare cases. It will not be possible to find a clear solution to many problems encountered in practice. Therefore, approximate methods play an important role in solving differential equations [5].

RESULT AND DISCUSSION

We can use a number of programming languages and tools to create software based on the algorithms developed above. We do not know the exact solution of the harmonic motion of a piece of cotton on an oscillating mesh surface. That's why we can't take the solution in the form of a table and compare it with the exact solution. By solving the problem in the given form (8) using the Runge-Kutta method, we can get the solution to the problem by constructing its graph.

Based on the algorithms built above, we conduct experiments using the MatLab software complex. Using equation (a) of the system of equations (7) and the values determined above, we obtain the results of the movement change in a graphical form by assigning values to the vibration amplitude (A) and frequency (ω) of the mesh surface (see figure 5):

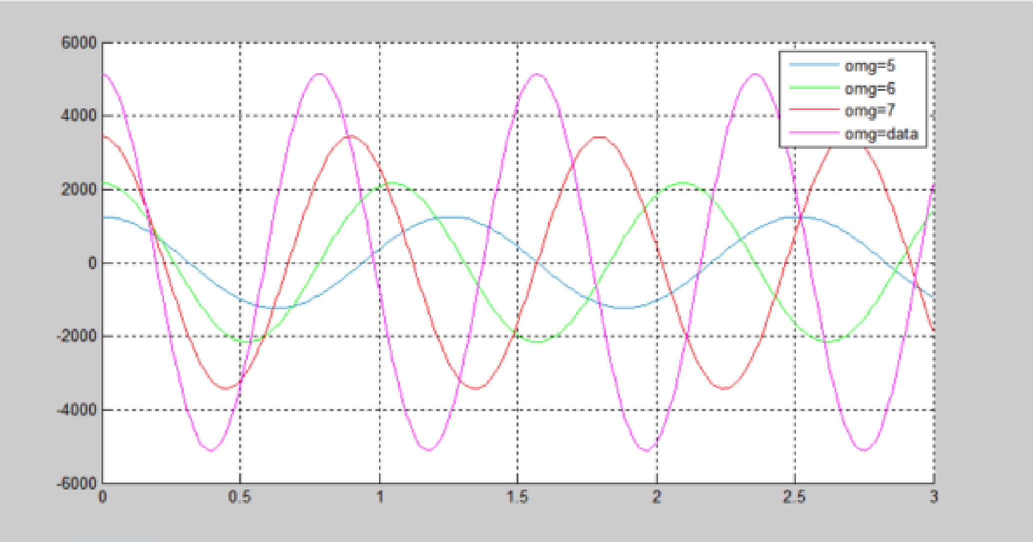


FIGURE 5. The results of the movement change in a graphical form by assigning values to the vibration amplitude (A) and frequency (ω) of the mesh surface.

From the obtained result, we can see that when the slope angle is α =26 degrees, the vibration amplitude is *A=20*, and the frequency is *ω=[5:8]*, the movement is uniform. Using the *Runge-Kutta* method based on the above algorithm, we get a graph of the speed of movement (see figure 6):

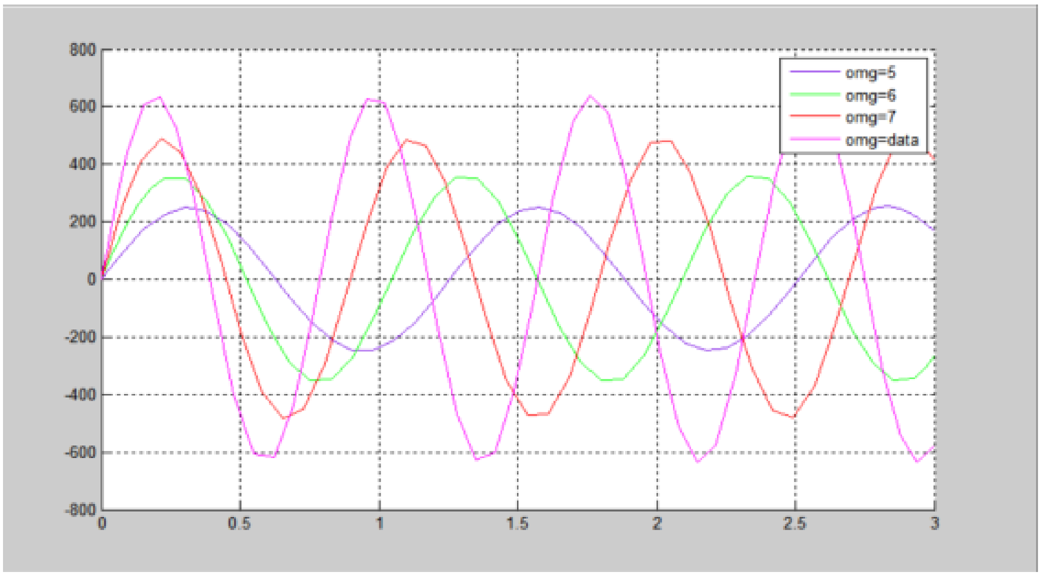


FIGURE 6. The slope angle is α =26 degrees, the vibration amplitude is $A=20$, and the frequency is $\omega=[5:8]$.

It can be seen from the graph (see figure 6) that the movement is uniform at the vibration amplitude $A=20$ and frequency $\omega=8$. In the above order, we get the results for the case where the slope angle is in the range t [0:5,0.1] degrees (see figure 7):

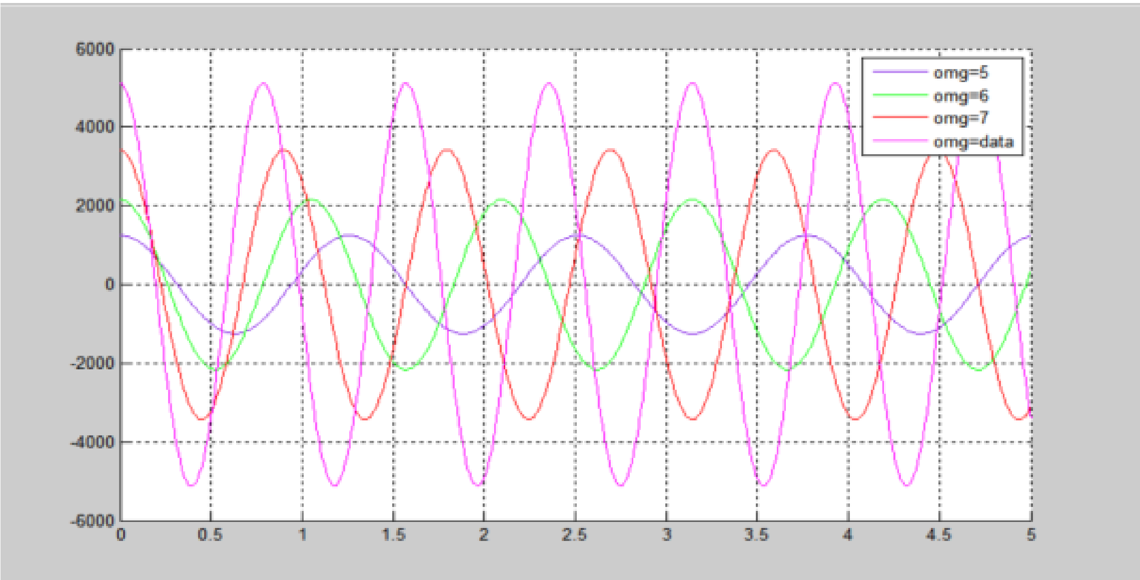


FIGURE 7. The vibration amplitude $A=20$ and frequency $\omega=8$.

From the obtained result (see figure 7), it can be seen that when the slope angle t is in the range [0:5,0.1] degrees, the vibration amplitude $A=20$, and the frequency $\omega=[5:8]$ the intermediate movement is uniform. Using the *Runge-Kutta* method based on the above algorithm, we get a graph of the speed of movement (see figure 8):

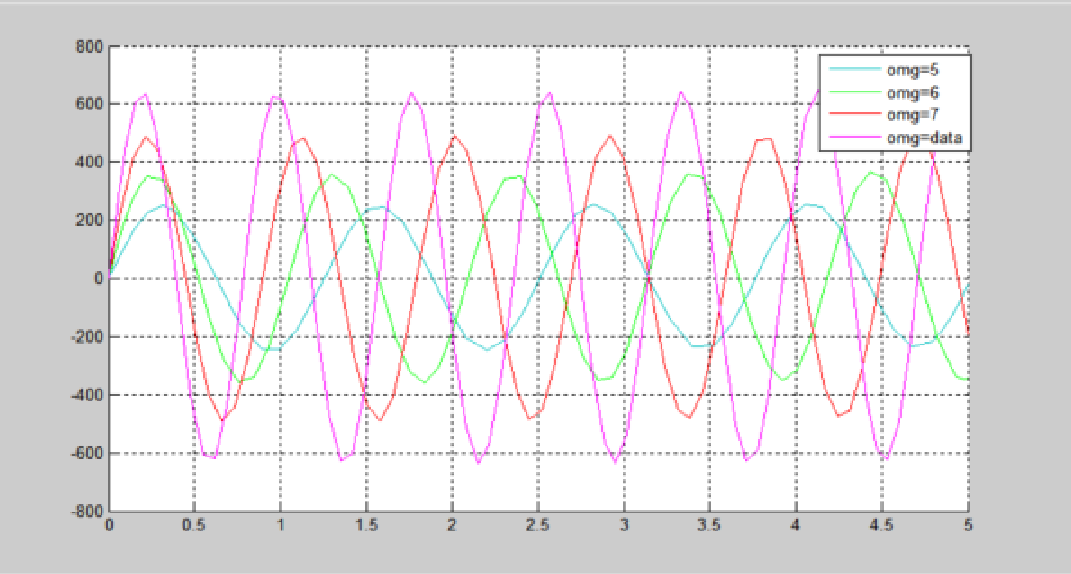


FIGURE 8. The slope angle *t* is in the range [0:5,0.1] degrees, the vibration amplitude $A=20$, and the frequency $\omega=[5:8]$.

It can be seen from the graph (see figure 8) that the movement occurs in the same plane at the vibration amplitude $A=20$ and frequency $\omega=8$. In the above order, we get the results for the case where the slope angle is $\alpha=29$ degrees (see figure 9):

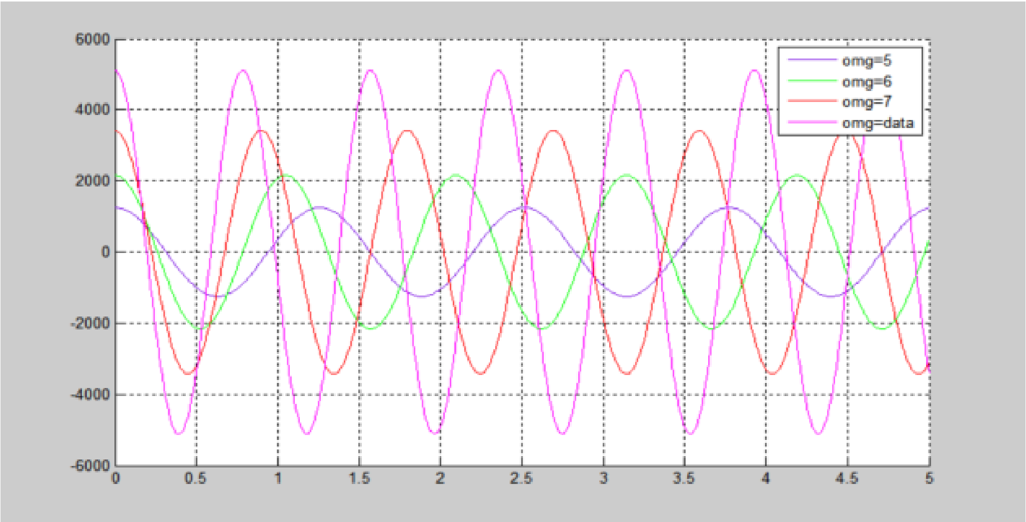


FIGURE 9. The slope angle is α =29 degrees, the vibration amplitude is $A=20$, and the frequency is $\omega=8$.

From the obtained result (see figure 9), it can be seen that when the angle of inclination is $\alpha=29$ degrees, the vibration amplitude is $A=20$, and the frequency is $\omega=[5:8]$. Using the *Runge-Kutta* method based on the above algorithm, we get a graph of the speed of movement (see figure 10):

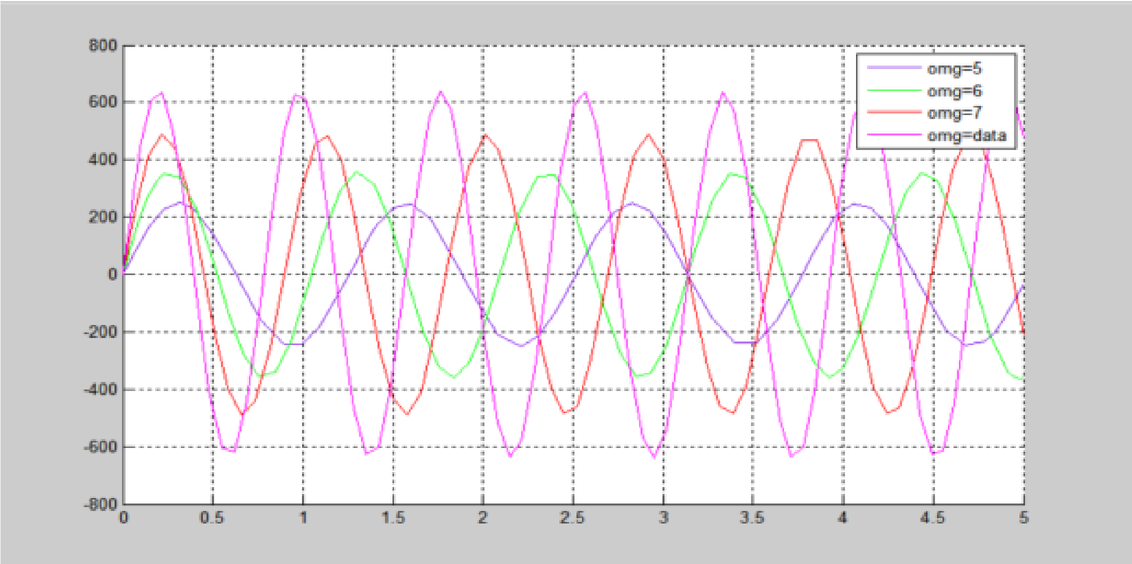


FIGURE 10. The slope angle is α =29 degrees, the vibration amplitude is $A=20$, and the frequency is $\omega=[5:8]$.

It can be seen from the graph (see figure 10) that the movement is uniform at the vibration amplitude $A=20$ and frequency $\omega=8$. The window for performing calculation experiments is very simple, in which values for the friction coefficient of the mesh surface (μ), the angle of inclination with respect to the horizontal plane (α), the vibration frequency (ω), and the amplitude (A) are entered, and the result button is pressed (see figure 11).

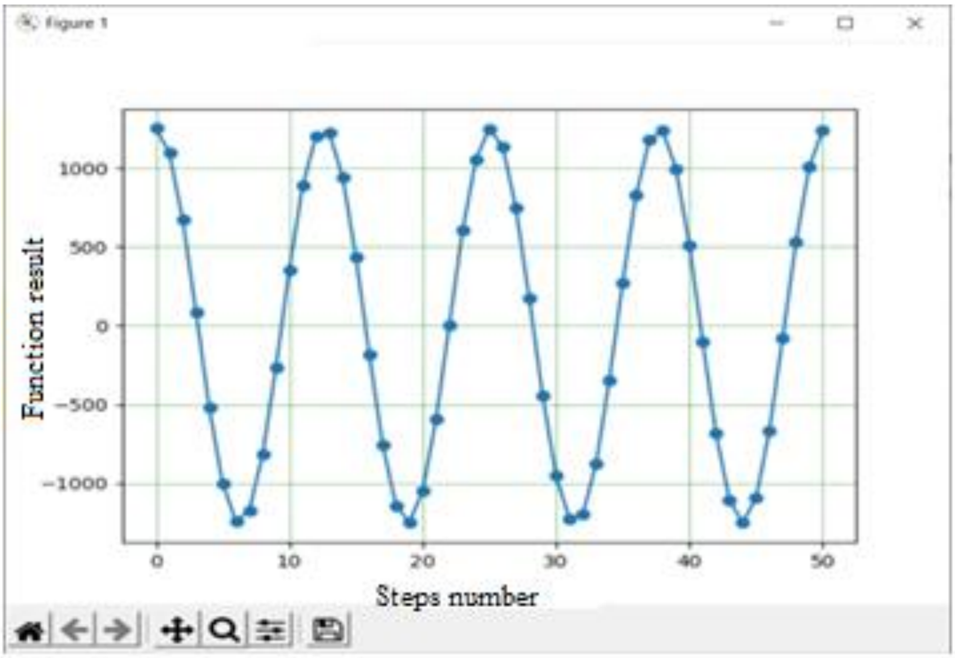


FIGURE 11. Getting the results from the program.

As a result of the above research, the slope angle $\alpha=[26^0; 29^0]$, it was determined that the motion is uniform when the friction coefficient takes values of μ=1 when the amplitude is *20 mm* and the number of vibrations is *8 Hz*.

CONCLUSION

Since it is very difficult to find an exact solution to differential equations, it was necessary to use approximate methods. Therefore, we used graphical methods. In these cases, the solutions were expressed in graphic forms.

Given that the considered problem is a first-order ordinary differential equation and its initial condition is known, we consider it a Koshi problem, and the solution in the form of graphical representations of the results obtained using the Matlab system through the system of ordinary differential equations and Runge-Kutta methods we got From the obtained results, it can be concluded that the angle of inclination of the separator relative to the horizon is $\alpha=(26:29)$degrees, the vibration amplitude is $A=20mm$, and the frequency $\omega = (5:8)\ Hz$ is that the cotton ball vibrates uniformly.

In particular, while observing the movement of a piece of cotton oscillating on the mesh surface of an inclined plane, it was observed that in the movements that occurred at small values of the angle of inclination $\alpha=26$, the speed of cotton movement slows down, and otherwise, the speed of cotton movement increases. In addition to these, inventions are made to create cleaning devices that work on new technology to improve the quality of fiber, and the optimal parameters of the device, which are the basis for improving the quality of fiber, are determined by mathematical modeling and software tools.

REFERENCES

1. Ataullaev A.Kh., Ravshanov N. Research on the process of separating loose seeds of cotton and rushanka. - Moscow. – 1989. N 2035.
2. Ravshanov N., Computer modeling of technological processes of separation of mixtures. / N. Ravshanov - Tashkent "Adabiyot uchqunlari", 2014.-308 p.
3. Theoretical and Experimental Studies of the effect of inclуned Scraper on Raw Cotton from mech Surface. World Journal of Mechanics, USA.2014,4, 371-377.http//dx.,doi.org/10.236/wjm.2014.412036. Published Online Desember 2014 in Scires. http://www.scrip.org/journal/wjm.
4. Pogorelova A.S. Development of a mathematical model for the separation of loose mixtures that are difficult to separate, taking into account the strength of the air flow / journal, Fundamental research. - 2015. - No. 2 (part 17) - p. 3718-3722.
5. Akhmedkhodzhaev Kh.T. , Umarov A.A. Technology and equipment of the industry / textbook. Namangan-2015.

6. Khashimov S., Kholmirzaev I., Otabaev B. Mathematical model of a body moving in an inclined plane and its software. Republican scientific-practical conference "The role of innovative educational technologies in improving the quality of education: problems and solutions" Namangan. March 29-30, 2019. Pages 302-304.

7. Khashimov S., Dadamirzaev M., Turgunov M., Otaboev B. Development of cotton cleaning technology and design of efficient devices using air flow. Republican scientific and practical conference "Improving the efficiency of industrial enterprises through the diversification of investments." Namangan, 2019 June 7-8, pp. 296-298.

8. Khashimov S., Erkinov H. Development of a mathematical model of the process of cleaning cotton from small impurities. XV Scientific and practical conference of professors, teachers and students on the topic "Development of information and communication technologies and software", Samarkand branch of the Tashkent University of Information Technologies named after Muhammad al-Khwarizmi, March 5, 2020, part 2.

9. Khashimov S., Erkinov. Kh., I. Makhamadzhanov. Mathematical modeling of some issues March 30-31, 2021 at the Namangan Civil Engineering Institute Republican scientific and practical conference on the topic "The role of information systems and technologies in modern society". Pages 143-146.

10. Khashimov. S., Ergasheva. S, Sobirov. Sh. Using the Autocad system in the structural design of a cotton gin. On March 30-31, 2021, a republican scientific and practical conference on the topic "The role of information systems and technologies in modern society" will be held at the Namangan Civil Engineering Institute.

11. Ravshanov. N, Khashimov. C. Problems of developing a technological process for cleaning cotton from fine particles and dust and their solution. ISSN 2181-8622 Scientific and technical journal of NamMTI, www.nammti.uz Scientific and technical journal of NamIET, volume 4 - Special issue No. 3, 2019.

12. Ravshanov. N, Khashimov. C. Development of a mathematical model of the process of cleaning cotton from small impurities. Scientific Bulletin of NamSU - Scientific Bulletin of NamSU No. 12, 2020, December.

13. Khashimov S. et al. Determination Of The Optimal Parameters Of The Cotton Cleaning Device Based On A Computational Experiment //Web of Scientist: International Scientific Research Journal. – 2022. – T. 3. – №. 5. – C. 2008-2016.

14. Sabitxan Xashimov, Xusniddin Erkinov Creating a mathematical model of movement in the process of cleaning cotton from dirt ISSN (Online): 2455-7838 SJIF Impact Factor : 6.260 Research &Development Volume: 5, Issue:2, February 2020 EPRA International Journal of (IJRD) Monthly Peer Reviewed & Indexed International Online Journal ISI I.F. Value : 1.241

15. Sabitkhan Hashimov, Irisqulov Farxod Sultonboyevich, Imamnazarov Erkin Dexkanaliyevich, Erkinov Husniddin Bakhtiyoro‘g‘li, Abdujalilov Sodiqjon Muhammadamin o‘g‘li Problems of Development and Solution of Technological Processes ofCleaning Cotton with Small Dispersion Particles and Dust/ Palarch’s Journal Of ArchaeologyOfEgypt/Egyptology 17(7),ISSN 1567-214x.

16. Ravshanov Normaxmad Kayumovich, Sabitxan Xashimov, Erkinov Husniddin Bakhtiyor oglu, Nuritdinov Nurbek Davlatalievich, G‘ofurjonov Muhammadyusuf Conducting Experiments on the Process of Cleaning Cotton Design Engineering ISSN: 0011-9342 | Year 2021 Issue: 8 | Pages: 11095 – 11103.