

DEVELOPMENT OF CONSTRUCTION OF A SCREW CONVEYER THAT TRANSPORTS AND CLEANS COTTON, JUSTIFICATION OF SCREW PARAMETERS

Yuldashev Ilhomjon Komiljonovich
Researcher of Andijan State University
ilxomjon0584@gmail.com

Abstract

In this article, the results of the development of the cotton transportation and cleaning screw conveyer construction, and the justification of the screw parameters are presented. Characteristics of interaction with the transported piece of cotton in the movement of the conveyer screw and connection graphs were built. Based on the analysis of the graphs of the parameters, the values of the screw pitch angle that ensure sufficient cleaning efficiency and high productivity have been determined.

Keywords: Screw conveyer, elevation angle, diameter, radial velocity, mesh surface, holes with a curved surface, friction, mass, inertia, centrifugal force, reaction, air velocity, transportation.

Introduction

It is known that the screw conveyer contains a fixed chute, the lower part of which has the shape of a semi-cylinder, closed top cover, and installed inside the chute along its axis, the drive screw in bearings mounted on the chute. The lower working part of the gutter is made in the form of a mesh surface. The movement of the load along the chute is carried out by turns of the rotary screw [1].

The disadvantage of this screw conveyer design is the high energy consumption and the possibility of slaughtering the cargo in the chute with increased material supply.

Another well-known conveyer contains a chute, the lower part of which has the shape of a half-cylinder, closed on top with a lid. Annular bandages are attached to the chute in the lower cylindrical part, by means of which the chute is mounted on rollers with the possibility of oscillating the chute around its axis. The rollers rest against the end surfaces of the annular bandage on the gutter. The chute for the possibility of oscillation is suspended on bearings on the screw shaft. The cover has an inlet on the left side, and the chute has an outlet on the right side [2].

The disadvantage of this design is the impossibility of removing weed impurities from the total mass of the transported cotton seeds, which are released as a result of the screw movement. As a result, the selected weed impurities enter the technological linter machine and heavily pollute the resulting lint product (clap).

The next well-known screw conveyer design contains a chute with a lower semi-cylindrical part, a screw installed with the possibility of oscillation around its axis, holes installed inside the chute along its axis, holes made in bearings fixed in the lower semi-cylindrical part of the chute [3]. The disadvantage of this design is the insufficient transportation of bulk material



(cotton, fibrous waste) due to significant deceleration of the material due to their interaction with the edges of the holes and insufficient friction between the surface of the screw turns and the transported cotton.

In a screw conveyor containing a chute with a lower semi-cylindrical part and a lid mounted on top, a drive screw with a curved working surface is installed along its axis inside the chute, while the curved working surface of the screw turns is made in a zigzag shape. The height of the triangular protrusions is from 4.0 to 7, 0 mm [4]. The disadvantage of this design is the low effect of isolation and removal of weeds from cotton.

It should be noted that in the existing screw conveyers during the transportation of fibrous materials, especially cotton, due to insufficient loosening of the material, insufficient litter is released. In addition, due to insufficient friction between the helical surface and the fibrous material, they lag behind during transportation, which leads to additional mechanical damage to the fibrous material (cotton and their waste). The interaction of the helical surface on the fibrous material occurs monotonously in one direction, with a constant moving force, which does not ensure the efficiency of their cleaning. The design of the mesh surface does not provide intensive loss of selected weed impurities through them.

Development of an effective screw conveyor structural scheme

In order to ensure the necessity of loosening the transported fibrous material and the uniformity and cleaning of the entire length of the screw conveyor, as well as the intensive drive, the structure of the screw conveyor is improved. It is improved by increasing the contact area, increasing the friction force, as well as changing the direction of the interaction force of the screw with the transported material along the entire length of the screw conveyor along the vibrating mesh surface.

The essence of the design lies in the fact that the screw conveyor contains a fixed chute, the lower part of which has the shape of a half-cylinder, closed from above by a lid, and a drive screw installed inside the chute along its axis in bearings fixed on the chute. The lower working part of the gutter is made in the form of a mesh surface. The movement of the load along the chute is carried out by turns of a rotating screw, the working surface of the turns of the screw can be made wavy. The lower part of the chute is attached to the upper part by means of rubber gaskets (shock absorbers) and is divided into three parts along the length. The thickness of the rubber shock absorbers is made to fit in the direction of the transported material, and the holes of the mesh surfaces are made curvilinear, and installed perpendicular to the generatrix of the screw. At the same time, the radius of the holes' curvature is made increasing in the course of pulling the material along the length of the screw.



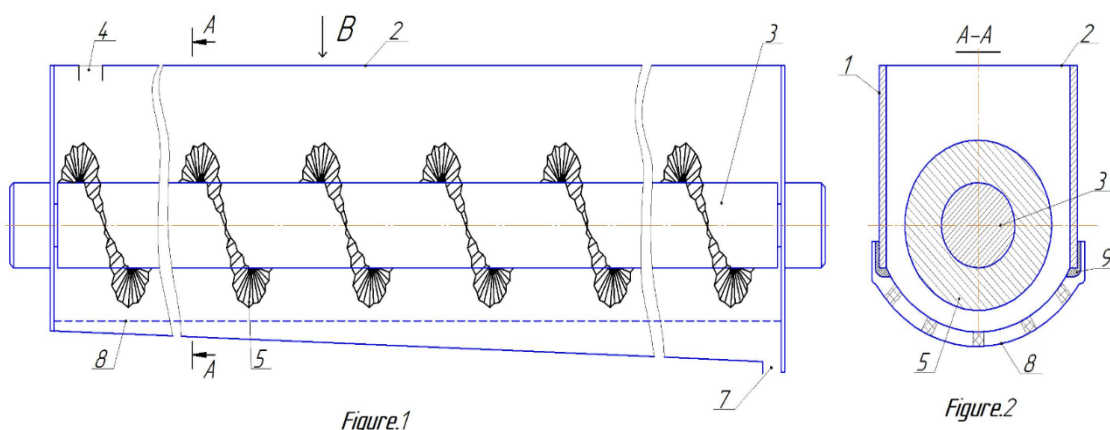


Figure.1

Figure.2

It should be noted that in the initial area of the screw, the lint (cotton) will be less loosened, and at the end more loosened. Therefore, the vibration of the mesh surface in the first zone will be maximum due to the greater thickness of the rubber shock absorber (up to 5.0 mm), and in the third output zone with a minimum amplitude (the thickness of the rubber shock absorber is 3.0 mm). The radius of curvature of the mesh openings in the first zone allows its increased area to remove a large amount of litter, and in the exit zone, the area of the holes decreases and allows the removal of the remaining litter.

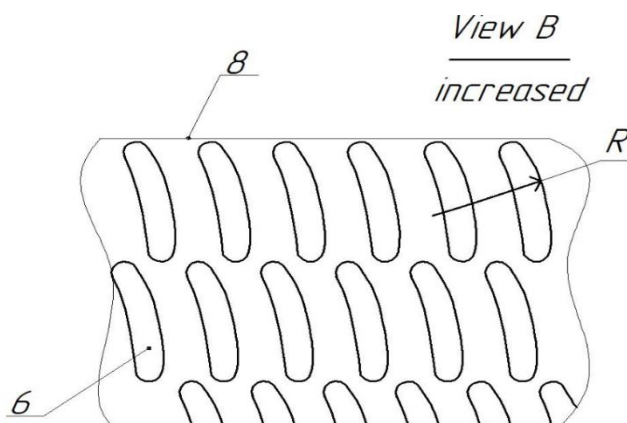


Figure.3

Figure - 1. Screw conveyor

The screw conveyor contains a chute 1, the lower part of which has the shape of a half-cylinder, closed from above by a lid 2. Inside chute 1, along its axis, screw 3 transports the material. At the top of chute 1, there is an inlet 4, and at the end, at the bottom, there is outlet 7. The lower working part of gutter 1 is made in the form of a mesh surface 8. The working surface of the screw (coil) 3 can be made in a wavy shape 5. The lower part 8 of the gutter is made in the form



of a mesh surface with curved holes 6 attached to the gutter 1 by means of rubber gaskets (shock absorbers) 10. In this case, the mesh surface 8 is divided into three equal parts along the length of screw 3, and the thickness of the rubber pad 9 is chosen to fit in the direction of material transportation. The curvature radius R of hole 6 is made increasing in the course of transporting the material.

The design works as follows. Fibrous material (raw cotton, fibrous waste) is fed into chute 1 through inlet 4 in lid 2 and, when screw 3 is rotated, it slides along chute 1 dragged by the free-form working surface 5 of the rotating screw 3 to the output hole 8. The wavy surface 5 of the working surfaces of screw 3 acts on the seeds and cotton bats (lint) with a force of different magnitude and direction, which leads to additional loosening of the cotton, this allows for the effective separation of litter from the fibrous material (cotton). Weed impurities isolated from the fibrous material fall out through holes 6 of the mesh surface 8 of trough 1 and are discharged into the self-removal through hole 7.

In the first of the three zones along the length of the screw conveyer, the mesh surface 8 will make complex oscillations with large amplitude due to the large thickness of the rubber pad (shock absorber) 9. This allows intensive loosening and separation of litter from the transported cotton (lint). In the first of the three zones along the length of the screw conveyer, the mesh surface 8 will make complex oscillations with large amplitude due to the large thickness of the rubber pad (shock absorber) 9. This allows intensive loosening and separation of litter from the transported cotton (lint).

Analysis of the cotton piece movement on a mesh surface along the screw surface in a screw conveyer.

In order to effectively separate the waste from the cotton pieces in the proposed conveyer for cleaning and transporting cotton pieces, the holes on the mesh surface are made curved and equal to the angle of the screw surfaces. It is important to determine the law of motion in the interaction of the cotton piece with the surface of the screw and to justify the angle of elevation of the screw.

Figure 2 shows the calculation scheme for the impact of a screw on a piece of cotton. The calculation scheme is mainly affected by the following forces in the process of transportation and cleaning of a piece of cotton: \bar{G} - gravity; \bar{R} - the reaction force of the screw surface to the piece of cotton; \bar{F}_h - the force of airflow; \bar{F}_k - Coriolis force; $\bar{F}_{m,t}$ - centrifugal force; \bar{F}_{iv} - the frictional force between the piece of cotton and the surface of the screw; \bar{F}_{it} - is the force of friction of a piece of cotton with a mesh surface; \bar{F}_I - inertial force.

The movement of the cotton piece on the surface of the conveyer screw in the transportation and cleaning zone along the “X” and “Y” axes was determined using the second-order Lagrange equation [5, 6]:

$$m_p \ddot{X} = F_{iv} - F_{kor} \sin \beta - F_{IT} \cos \alpha \quad (1)$$

$$m_p y = F_{ir} - F_x - F_{kor} \cos \beta - F_{it} \sin \alpha - R$$



where, m_p – the weight of the lint piece; β - the angle that forms the centrifugal force vector with the “X” axis; α - the screw pitch angle.

If the force of friction of the piece of cotton with the surface of the screw is considered to be $F_{ir}=f_vR$ and the movement of the piece of cotton along the y-axis is zero, the following differential equation is formed:

$$m_p \ddot{X} = m_p \omega_v^2 R_v \sin \beta + f_v F_{kor} - f_v K V_h^2 - f_b m_p \omega_v^2 R_v \cos \beta - f_v f_T m_p g \sin \alpha - f_t m_p g \cos \alpha \quad (2)$$

Where, ω_v - conveyer screw radial velocity; R_v - screw radius; f_v , f_T - coefficients of friction of a piece of cotton with a screw and mesh surface; V_h - air flow rate; g - free-fall acceleration.

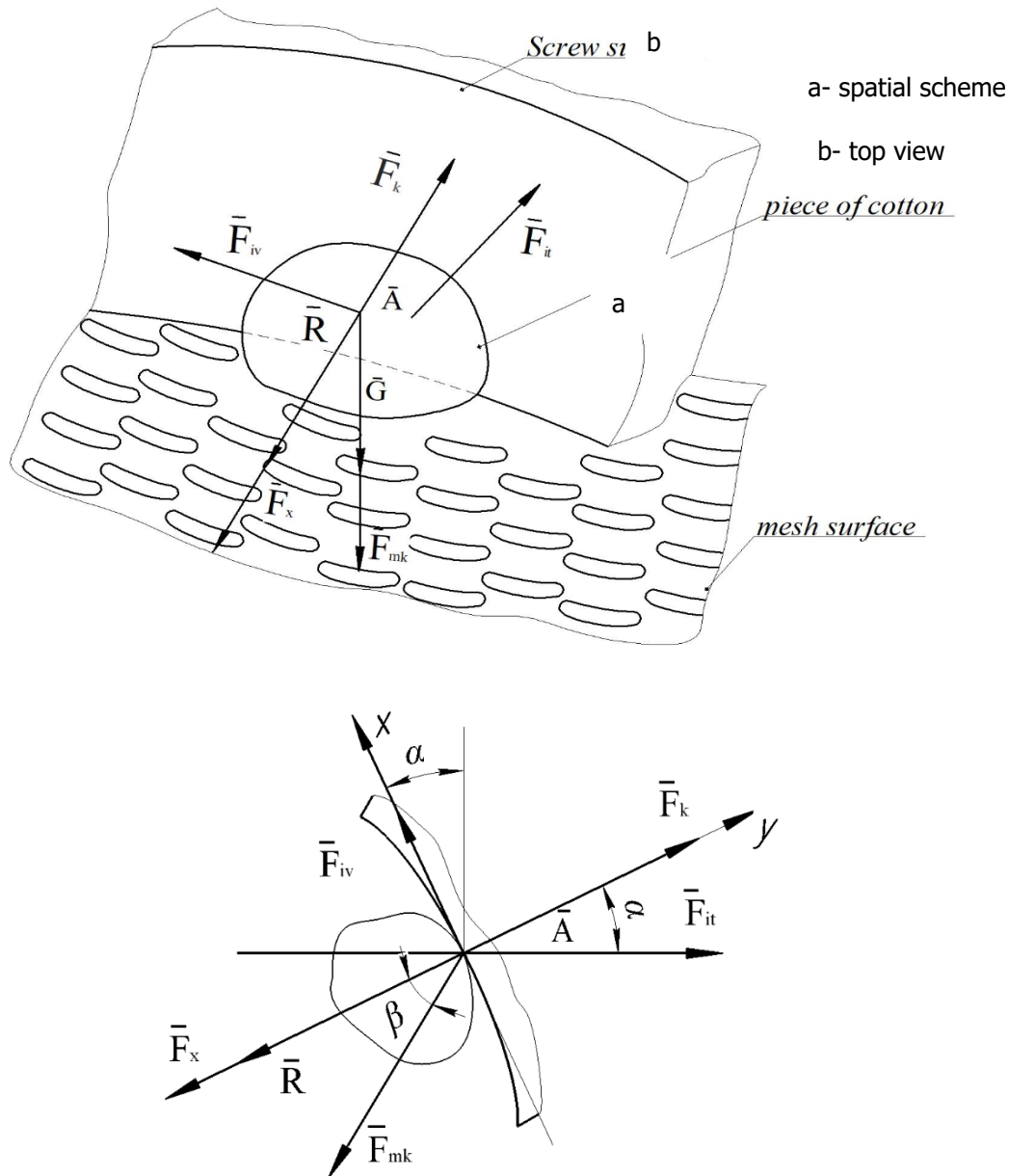


Figure 2. Calculation scheme representing the force vectors acting on a piece of cotton by a conveyer screw.



A piece of cotton has five degrees of freedom during cleaning and transportation on a conveyer belt [7]. In this case, the piece of cotton does not move only in the direction perpendicular to the mesh surface. In order to reduce the entanglement and damage of its fibers during the movement of a piece of cotton, the optimal value of the α -angle is in the momentary movement, i.e. $t \rightarrow 0$, It is defined when $X=0$; $\dot{X}=0$; $\ddot{X}=0$. Using this condition, it will be possible to determine the angle of the rise of the conveyer screw, that is, the angle of impact of the cotton ball [7, 8].

In this case, the following expression emerged from (2):

$$f_v F_{kor} - m_p \omega_v^2 R_v \sin \beta - f_v K V_h^2 - f_v m_p \omega_v^2 R_v \cos \beta - f_v f_T m_p g \sin \alpha - f_T m_p g \cos \alpha = 0 \quad (3)$$

It is known that a piece of cotton should not slip when it is kept on the surface of the screw and moved along the mesh surface. In this case, a piece of cotton remains on the surface of the screw. It is considered that $f_v=1.0$ so that the cotton piece (lint) does not slip on the surface of the screw. According to trigonometric relations [9,10]:

$$\sin \alpha + \cos \alpha = \sqrt{2} \cos \left(\frac{\pi}{4} - \alpha \right) \quad (4)$$

In this case, we create a formula for determining the angle of elevation of the screw:

$$\alpha \leq \frac{\pi}{4} - A$$

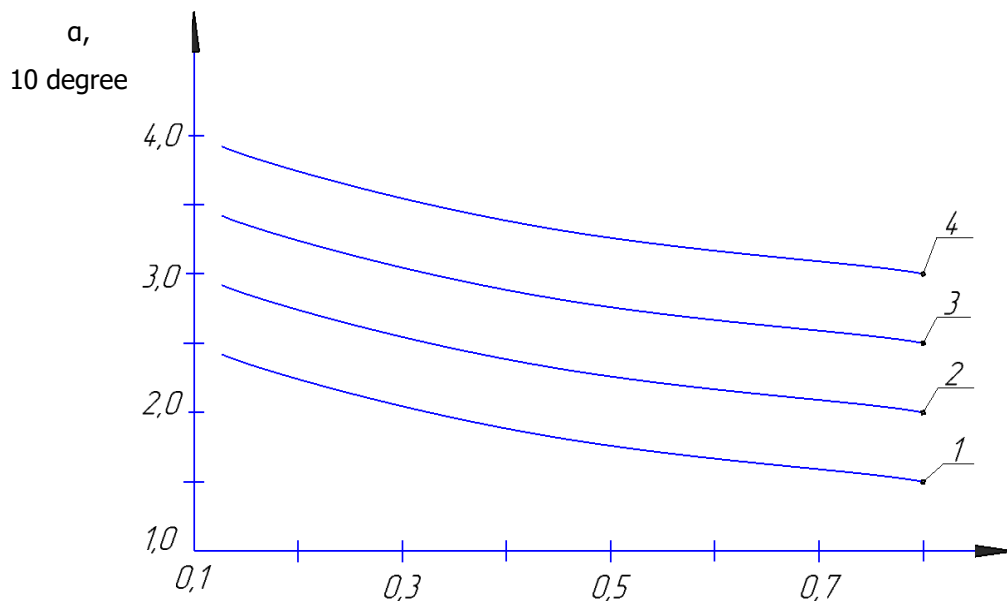
$$A = \arccos \left[f_v F_{kor} - f_v K V_h^2 - f_v m_p \omega_v^2 R_v \cos \beta - m_p \omega_v^2 R_v \sin \beta \right] \frac{1}{\sqrt{2} f_v f_T m_p g} \quad (5)$$

Numerical solution of the problem and analysis of the results. The numerical solution of the expression (5) for determining the pitch angle of conveyer's screw was carried out at the following initial values of the parameters [11,12]: $m_p=(0,15 \div 0,85)10^{-3} \text{kg}$; $f_v=(0,3 \div 1,0)$; $f_T=(0,2 \div 0,4)$; $\omega_v=(3,0 \div 4,0) \text{s}^{-1}$; $g=9,8 \text{m/s}^2$;

$R_v=0,15 \text{m}$; $t_v=0,21 \text{m}$; $\alpha_{v0}=30^\circ$; $\beta=(25^\circ \div 35^\circ)$; $V_h=(0,45 \div 1,2) \text{m/s}$; $K=(0,2 \div 0,3)$

The numerical solution for determining the angle of elevation of the conveyer screw was carried out using the Runge-Kutta EHM program. As a result, the system parameters and screw diameter, angular speed, coefficients of friction of the cotton piece with the screw surface and mesh surface, the mass of the cotton piece, and the influence of the airflow speed on the screw pitch angle were obtained. In particular, Figure 3 shows graphs of the change in the angle of elevation of the conveyer screw as a function of the cotton piece mass and the screw diameter. It is known that increasing the mass of a piece of cotton makes it difficult to transport. In this case, it is necessary to sufficiently reduce the angle of the rise of the screw. According to the analysis of the obtained connection laws, when the mass of the cotton ball increases from $0.15 \cdot 10^{-3} \text{kg}$ to $0.8 \cdot 10^{-3} \text{kg}$ and $R_v=0.2 \text{m}$, the elevation angle of the conveyer screw decreases from 21.8° to 13.1° in the nonlinear connection. However, when the cotton piece weight is $R_v=0.11 \text{m}$, the effect on the angle "a" increases almost parallel, and it can be seen that it decreases from 36.7° to 24.9° (Figure 3, Graph 4). So, the better the cotton is, the higher the angle of the auger should be when transporting it.





1- $R_v=0,2m$; 2- $R_v=0,17m$; 3- $R_v=0,14m$; 4- $R_v=0,11m$;

Figure - 3. Graphs of the dependence of the change of the conveyer screw elevation angle on the cotton piece (lint) weight $m_p, 10^{-3}kg$ and the diameter of the screw.

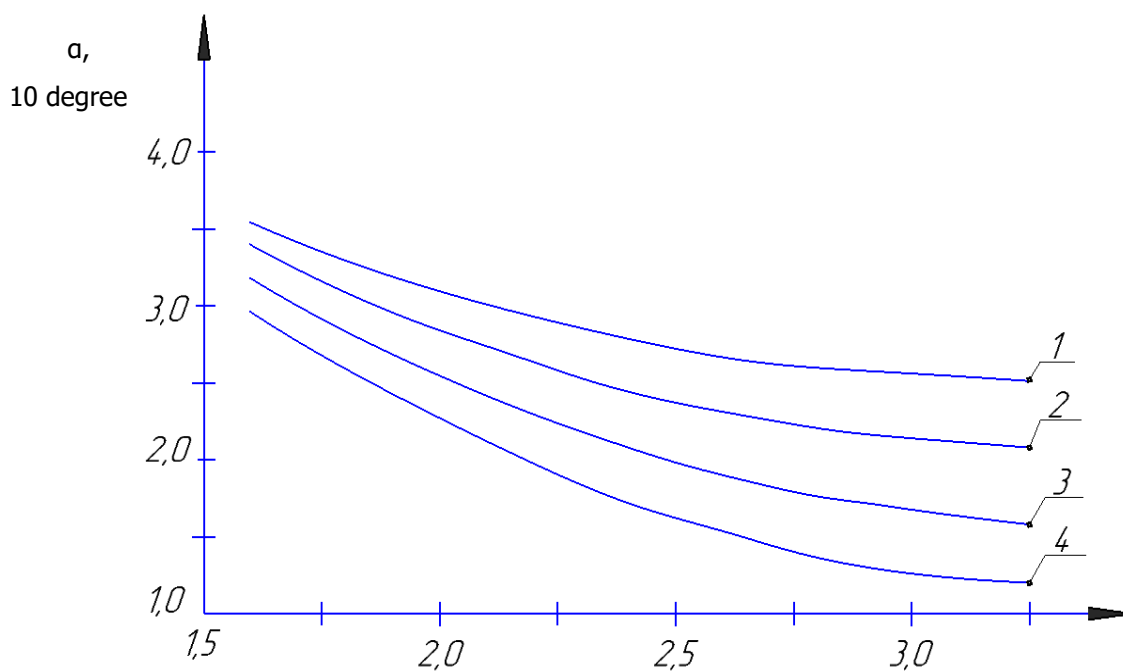


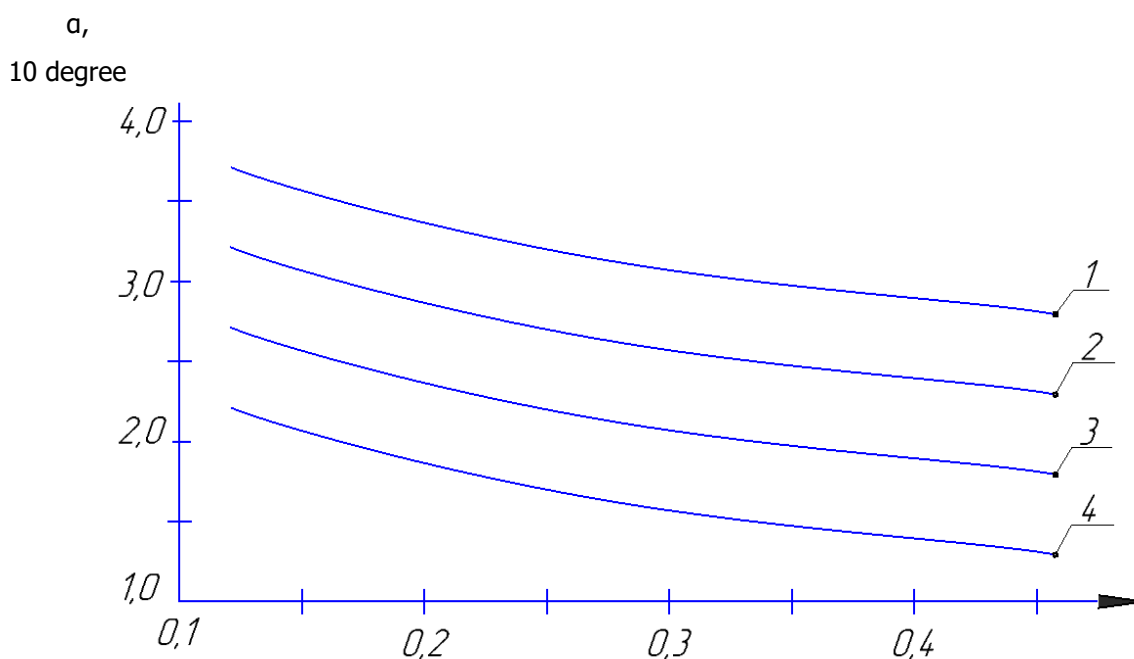
Figure 4 shows the relationship between the change in the angle of elevation of the conveyer screw elevation angle and the change in the radial speed of the screw.

1- $m_p=1,15 \cdot 10^{-3}kg$; 2- $m_p=0,3 \cdot 10^{-3}kg$; 3- $m_p=0,45 \cdot 10^{-3}kg$; 4- $m_p=0,62 \cdot 10^{-3}kg$

Figure - 4. Graphs of the dependence of the conveyer screw pitch angle change on the radial speed of the screw ω, s^{-1}



Based on the analysis of the graphs, when the values of the radial speed of the conveyer screw are increased from $1.8s^{-1}$ to $3.5s^{-1}$ and $m_p=0.62 \cdot 10^{-3}kg$, the values of the screw elevation angle α decrease linearly from 28.1° to 12.1° . Accordingly, when the values of ω_v decrease to $3.5s^{-1}$ and the cotton piece (lint) weight are $0.15 \cdot 10^{-3}kg$, the elevation angle of the conveyer screw decreases from 32.2° to 25.3° in a non-linear connection. Therefore, the high radial speed of the screw shaft leads to the transportation of cotton pieces, that is, to increase productivity. In this case, it is required that the cotton pieces are sufficiently shredded. Recommended values: $\omega_v=(2.7\div 3.2)s^{-1}$, $m_p\leq(0.15\div 3.2) \cdot 10^{-3}kg$. It is ensured that the conveyer screw elevation angle is between $(28^\circ\div 30^\circ)$.



1- $R_v=0,2m$; 2- $R_v=0,17m$; 3- $R_v=0,14m$; 4- $R_v=0,11m$;

Figure - 5. Graphs of the dependence of the conveyer screw elevation angle on the friction coefficient of the cotton piece with the mesh surface and the change of the screw radius.

Figure 5 shows the graphs of the dependence of the conveyer screw elevation angle on the friction coefficient of the cotton piece with the mesh surface and the change of the radius. Above, when determining the angle of the rise of the screw, the cotton piece is transported without slipping on the surface of the screw, that is, the coefficient of friction is assumed to be conditionally equal to one. But in the process of transportation and cleaning of cotton, it is important to change the coefficient of friction with the mesh surface with a curved profile. When this friction coefficient increases from 0.15 to 0.4, the conveyer screw elevation angle “ α ” decreases nonlinearly from 34° to 27.6° when the values of $R_v=0.2m$, when the screw radius is reduced to 0.19m, the angle “ α ” values decrease from 17.3° to 13.4° . Therefore, in order to increase the values of f_t , the holes with a curved shape are made perpendicular to the direction of movement of the cotton pieces. Recommended values: $f_t\geq(0.5\div 0.35)$; When $R_v=(0.17\div 0.2)m$, the values of α are ensured to be $(28^\circ\div 36^\circ)$.



Conclusion

The design of the screw conveyor for transporting and cleaning the cotton was developed, based on the values of the screw parameters. Based on the analysis of the movement of a piece of cotton on a mesh surface with the surface of the screw in the screw conveyor, the recommended values of the screw rise angle have been determined.

References:

1. Spivakovskiy A.O. and Dyachkov V.K. Transport vehicles. Ed. 2nd revision And extra. M., Mechanical engineering, 1968, p. 356.
2. Shukurov M.M. etc. Patent Res. Uzbek Screw conveyor. UZ IAP 032701 Bull. No. 2, 2007.
3. Abdugafarov X.J. etc. Patent Res. Uzbek Screw conveyor. FAP No. 01141 Bull. №10, 2016
4. Djuraev A et al. Screw conveyor. Patent UZ IAP 06472, Bull. №5, 2021
5. Djuraev A, Yuldashev K. Scientific basis of improvement of screw conveyor design of technological machines. Monograph, Uzb "Usman Nasir media", Namangan, 2022, 140 p.
6. Djuraev A. 1987 Dynamics of working mechanisms of cotton-processing machines (Tashkent: Fan) 168 p.
7. Yunusov S Z, Khaidarov A and Bobomurodov T G. 2013 Machine unit with the mechanism of a composite cylinder of technological machines Theory of machines and working process MNPk 2013 pp 26-7
8. Mansurova M A, Madrakhimov Sh and Umarova Z M 2016 Analysis of the influence of the lengths of the coupler and rocker arm links on the position of the flat four-link mechanism Theory of mechanism and machines 14 1(2)pp 21-9
9. Djuraev A, Zukhriddinov A, Mukhammedjonova S, Mavlonova I and Tursunova G 2020 Dynamics of machine aggregates with mechanisms of working bodies for cleaning cotton from fine impurities. Solid State technology. Blind Peer Review Referred Journal 63(6) pp 169-81
10. Djuraev A, Sayitkulov S, Bozorov B. Investigation of working bodies of cotton cleaning machine // Modern Innovation, System and Technologies, 2021, 1(4).
11. Djuraev A, Yuldashev K, "Dynamics of the Screw Conveyor for Transportation and Cleaning of Fiber Material". International Journal of Advanced Science and Technology. Vol. 29, No. 5, (2020), P. 8557-8566. ISSN: 2005-4238.
12. Djuraev A, Mamakhanov A, Yuldashev K, "Improvement of the term of service life of the drive roller chain of transmission". International Journal of Advanced Research in Science, Engineering and Technology. Vol. 6, Issue 3, March 2019 P. 8508-8514. ISSN: 2350-0328.
13. Djuraev A, Yuldashev K, Teshaboyev O. "Results of experimental determination of torque moments and noise on fluff transporter and cleaner screw conveyor shafts". Tashkent State Technical university named after islam karimov "Technical science and innovation" 2022, №3 188-196 6 ISSN 2181-0400



14. Djuraev A, Yuldashev K, Teshaboyev O. Results of experimental determination of torque moments and noise on fluff transporter and cleaner screw conveyor shafts. Technical science and innovation journal №3/2022. p 188
15. Djuraev A, Yuldashev K, Teshaboyev O. Determination of radial speed in screw conveyor shafts based on experimental research. Scientific Journal Research and education Volume 1, Issue 8. 2022. p 192.