Improvement of the machine for wool scutching for obtaining ecologically clean fiber

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Abstract. The article covers natural wastes emitted from wool in the loosening process. The results of experimental research of the amount of ecologically clean fiber are shown. Analytical research of scientific and technical information about technologies and technical means of primary processing of wool, as well as previous research in this area has been carried out. Improvement of the technological parameters of machines for loosening wool by adapting them to the characteristics of local wool has been studied. The dependence of the separation of contaminants from the composition of wool on the design of the fire bar of the fire grate of the column structure and the density of the product in the working chamber has been determined. Based on the results obtained, it has been determined that the use of an improved wool loosener improved cleaning efficiency. It has been determined that during the testing process, an experimental sample showed high performance. It was determined that after the peg drums, the porosity of the wool doubled, and the density of the wool decreased by half. The development of a new design of a loosening machine for loosening and cleaning wool fibers has been shown in technological schemes.

1 Introduction

Cattle breeding is one of the most high-tech branches of livestock sector. Large material, technical and financial resources of both domestic and foreign investors are invested in this industry. These changes force not only large industrial enterprises, companies and agricultural producers, but also ordinary people to pay attention to the environmental side of the problem. This process will be improved with the advent of new technologies. (GOST 10376-77 Regenerated wool from industry and consumption wastes of wool and semi-wool materials. Specifications.) The analysis of the conducted studies shows that many aspects that affect the loosening and cleaning of woollen raw materials in the process of loosening wool have not been disclosed. Wool loosening, cleaning efficiency, as well as product quality indicators are not up to par. Despite the fact that a lot of research has been carried out to improve equipment for the primary processing of wool, the problems of creating a technology aimed at increasing the cleaning efficiency of the opening machine and allowing to preserve the natural properties of wool have not been studied sufficiently. The efficiency of cleaning

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in the process of loosening wool depends on the feeder and the design dimensions of the fire grate [1-3].

Rational indicators of cleaning wool in the process of loosening from contaminated impurities in its composition have been determined.

It is essential to prepare state standards for woolen raw materials produced in Uzbekistan. At the enterprises of primary processing of wool, mainly the wool of karakul sheep is processed, which makes up the volume of exports. Therefore, the technological parameters of karakul wool require experimental research. Prior to the arrival of processed wool at the primary processing plants, the necessary guidelines should be developed in order to determine the industrial grade of the incoming raw materials and reduce the degree of contamination.

A theoretical analysis of the influence of the peg drum on the wool mass in the working chamber, the influence of the fire grate on the cleaning efficiency is presented.

2 Materials and methods

Let us consider the influence of the geometric parameters of the edges (facets) of the fire grate on the cleaning efficiency, according to the following scheme (Figure 1).

Using $\dot{\theta}_1 = \frac{d\theta_1}{dt} = y(\theta_1) = \sqrt{z(\theta_1)}$ equation, we determine the relationship between time and the angle of rotation of the lock:

$$\omega_0 t = \int_{\theta_0}^{\theta_1} \frac{\exp[f(z-\theta_0)]dz}{\sqrt{1+\beta F_1(z)}} \qquad (1)$$

where $F_1 = F(z) - F(\theta_0)$, $\beta = 2g / R\omega_0^2$

Figure 1 shows the numerical graphs of the integral of equation (1), obtained for various values n (the share of fire bars contacting with a lock in the grate). In the calculations, the following is accepted $\theta_0 = 0$, $\theta_1 = 2.56$ rad, $R = 0.225$ m, $\omega_0 = 52 s^{-1}$, $f_0 = 0.3$

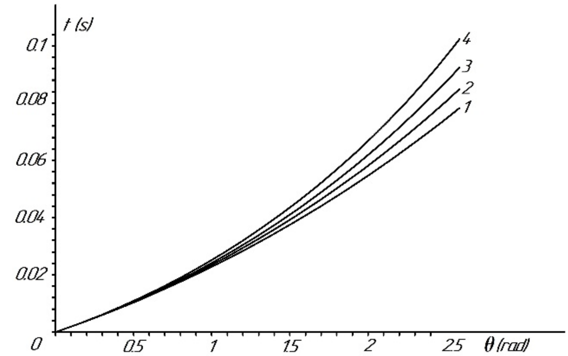

Fig. 1. The law of motion of a particle between two fire bars at different n at different times $t(s)$ $1 - n = 0.55$, $2 - n = 0.65$, $3 - n = 0{,}75$, $4 - n = 0.85$.

An analysis of the graphs shows that the time spent by the lock on the surface of the fire bar also increases with an increase in the contact surface of the fire bar with a lock. This can create the possibility of separating more contaminants from the lock [4-7]. In order to determine the number of pollutants emitted from a lock of wool moving along the surface of the fire bar, we will use the model proposed by A.G. Sevostyanov. According to this model, the relative decrease in the mass of a particle dm because of the separation of impurities will be proportional to the angular deviation of the particle $d\theta_1$, and this law is expressed by the following equation.

$$\frac{dm_1}{m_0} = -\lambda d\theta_1 \quad (2)$$

where, m_0 is the mass of the lock together with impurities between two pegs, λ is the coefficient of proportionality determined experimentally, in the general case, the coefficient depends on the angle θ_1.

We integrate equation (2) using the condition when $m = m_0 \ \theta_1 = 0$:

$$m = m_0 \exp(-\lambda\theta_1)$$

Relative number of separated contaminants (cleaning efficiency factor):

$$\varepsilon = \frac{m_0 - m}{m_0} = 1 - \exp(-\lambda\theta_1)$$

Where $\theta_1 = \theta_1(t)\,(1)$ is considered to be an undisclosed function of time t according to the formula. Fig. 2 shows graphs of the change in the function $\varepsilon = \varepsilon(\theta_1)$ at various values of λ for θ. From the analysis of the graphs, it can be seen that with an increase in the parameter of the λ coefficient, an intensive increase in its initial values is observed [8]. With its small values, the relationship between the angle and the coefficient is close to a straight line. The λ coefficient is considered a technological parameter, the value of which depends on the structure of the cleaned lock and the design of the fire grate. In an efficient technology, the value of the coefficient should be high. If the lock structure is complex and the separation of impurities is difficult, the value of this parameter will be small

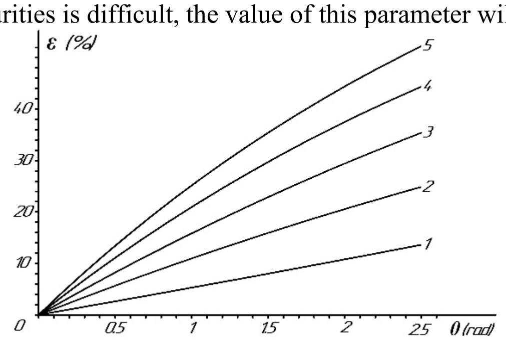

Fig. 2. Graphs of change in the coefficient of cleaning efficiency $\varepsilon(\%)$ at different values of λ depending on θ. $1-\lambda=0.05,\ 2-\lambda=0.1,\ 3-\lambda=0.15,\ 4-\lambda=0.2,$ $5-\lambda=0.25$.

The number of separated pollutants can be shown as an expression of its relative productivity Q/Q_0 using the following integral:

$$\frac{Q}{Q_0} = \int_0^{\theta_0} [1 - \exp(-\lambda\theta)] d\theta = \frac{\lambda\theta_0 - 1 + \exp(-\lambda\theta_0)}{\lambda}$$

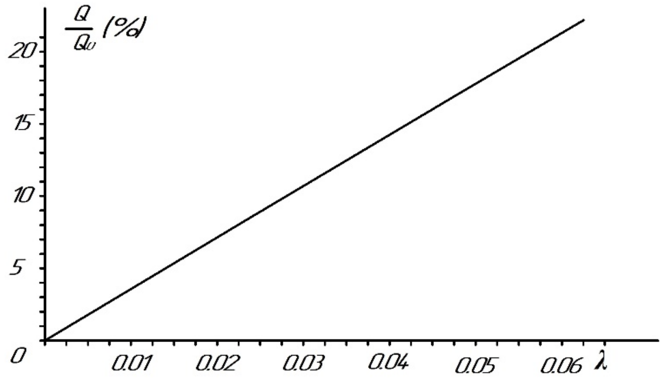

Fig. 3. Graph of the change in ecological waste Q/Q_0 (in percent), separated from the composition of the lock, depending on the parameter λ.

In practice, in order to use this graph, a special experiment is carried out on the sample, the ratio Q/Q_0 is determined and, accordingly, λ is determined from the graph, and by using this coefficient [9], based on theoretical calculations, it is possible to estimate the amount of impurities separated from the selected lock.

The model of A.G. Sevostyanov determines the differential form of the decrease in the mass of the fiber because of the separation of impurities from the composition of the wool.

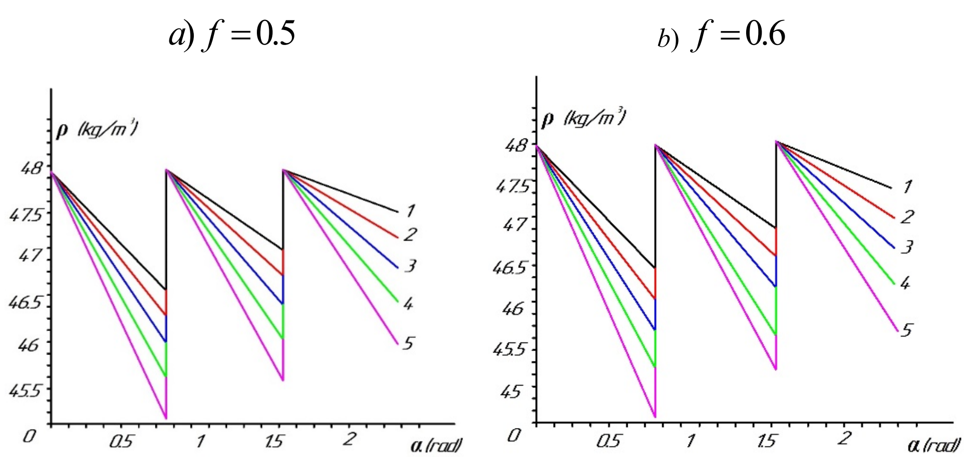

Fig. 4. Distribution of density $Q_0(kg/hour)$ along the cleaning arc for various input values of $f=0.5$ (a) and $f=0.6$ (f). $1-Q_0=500$, $2-Q_0=600$, $3-Q_0=700$, $4-Q_0=800$, $5-Q_0=900$.

A significant influence of the friction coefficient f on the amount of the polluting mixture has been determined.

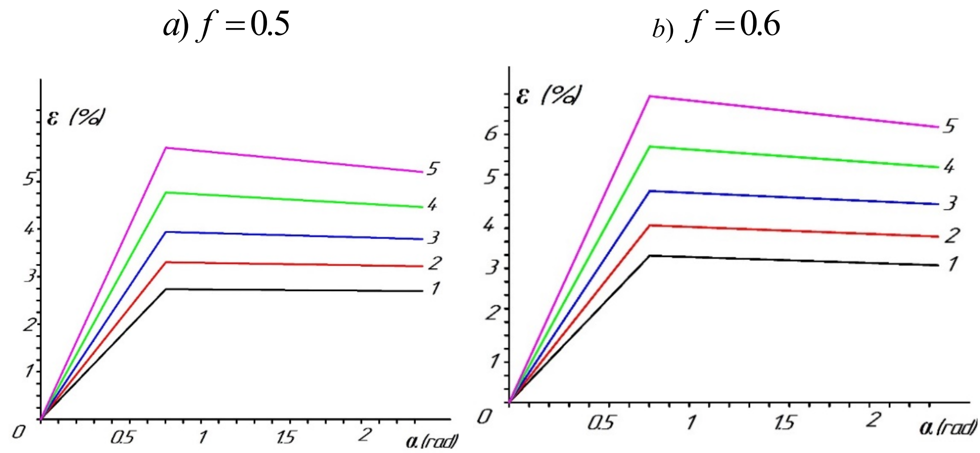

Fig. 5. Distribution of the efficiency coefficient ε of the cleaning arc for $f=0.5$ (a) and $f=0.6$ (b) at different values of $Q_0(kg/hour)$ $1-Q_0=500$, $2-Q_0=600$, $3-Q_0=700$, $4-Q_0=800$, $5-Q_0=900$.

The dependence of the separation of contaminants from the composition of wool on the design of the fire bar of the fire grate of the column structure and the density of the product in the working chamber has been experimentally established [10-12].

The amount of weed impurities in the composition of karakul wool has been studied and analyzed (Table 1).

Table 1. The amount of natural waste in the composition of karakul wool.

Type of wool	**Average impurity in wool composition %**					
	Fat and sweat	**Humidity**	**Weed impurities**	**Mineral mixtures**	**Dung**	**Fiber**
Karakul	11-12	10	3	4-14.5	2-2.5	58-80

Percentage of impurities in the raw material during and before the wool loosening process has been studied. Accordingly, it has been determined that coarse wool contains 20-32% of impurities, and 10-16% of all impurities are separated during the loosening process [13-15].

The amount of impurities in the composition of karakul wool varies depending on the shearing period (Table 2).

Table 2. Natural waste released from wool during the loosening process.

Karakul wool	**General impurities, %**	
	The amount of weed impurities released during loosening, %	**The amount of weed impurities released after loosening, %**
Autumn	10	10
Spring	13	14
High impurity	16	16

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Nowadays, wool loosening machine 2BT-150Sh is used at most enterprises of primary wool processing in the Republic.

As a result, technological defects in the loosening process have been revealed. Raw wool brought from farms, after sorting at enterprises, is loosened on loosening machines [13]. However, the amount of weed impurities in the wool composition after the loosening process is not checked. The main part of the separation of contaminants in the wool composition is carried out during the washing process. In order to eliminate these defects and shortcomings, a loosening machine, shown in Figure 6 is used.

a

b

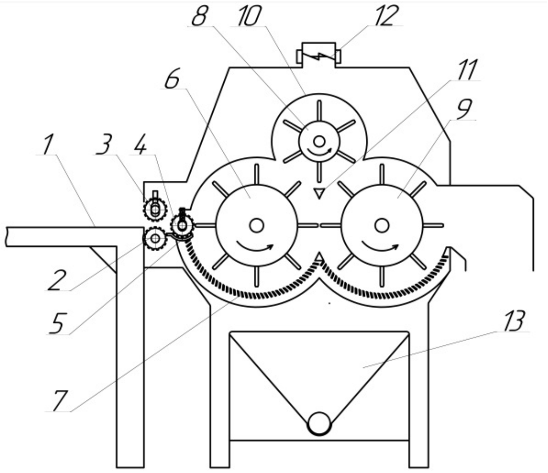

Fig. 6. a) ecological machine for cleaning wool from natural waste; b) constructive view of the proposed loosening machine. 1- feeding table for wool feed; 2- feed roller; 3- adjustable roller; 4- sealing roller; 5- table; 6, 9 - peg drum; 7- fire grate; 8- separating drum; 10- mesh surface; 11- trihedral fire grate; 12- fan; 13- bunker impurities.

3 Results and discussion

In the second stage, the experiments were carried out on the edge (facet) fire grate. In this case, autumn and spring karakul wool was used. In an experiment conducted on the edge (facet) fire grate equal to 400, the cleaning rate of autumn wool pollution improved from 12.1% to 14.5%. The cleaning efficiency of spring wool contamination increased from 16.0% to 20.2%.

Based on the results obtained, it was determined that the use of an improved wool opener increased cleaning efficiency from 10% to 14.5% for autumn wool and from 13% to 20.2% for spring wool.

By improving the technological process of loosening wool, cleaning efficiency and economic efficiency are achieved [16].

It was determined that during the testing process, an experimental sample of an effective wool loosening technology showed high performance.

The experiments were carried out at the private enterprise “Okbutayeva Zulhumor”, located in the Kurgantepa area of Dekhkanabad district of Kashkadarya region (Table 3).

Table 3. Amount of natural waste. Results of the experimental research.

No.	Indicators	Existing technological process		Proposed technological process	
		Autumn	Spring	Autumn	Spring
1	Humidity degree, %	10.0			
2	Density of wool before loosening, kg/m^3	48			
3	Density of wool after loosening, kg/m^3	33.6	38.4	28.8	24
4	Preliminary contamination, %	20	27	20	27
5	Cleaning efficiency, %	10	13	14.5	20.2
6	Separation of short coarse fibers, %	3.2	1.5	4.5	2

4 Conclusion

Based on the results of research on the development of improved technology for loosening wool, the following conclusions were drawn. The separation of wool into locks in the working chamber has been theoretically studied. The regularity of the action of the working members, which affects the efficiency of loosening, has been determined. The law of decrease in the density of wool and increase in the linear speeds of the movement of locks of wool during the initial action of the peg drum on the surface of the fire grate has been determined. It has been determined that after the peg drums, the porosity of the wool doubled, and the density of the wool decreased by half. As a result, pollution in the wool becomes passive, and weed impurities from the wool come to its surface. The interaction of wool with the working surface of the fire grate allows increasing the efficiency of loosening and cleaning. Increasing the cleaning efficiency of the machine in sections of the peg drums and increasing the linear speeds of the feed rollers leads to a decrease in the cleaning efficiency. When using a faceted grate, during the experiment, the cleaning efficiency was increased by

14.5%. When the technological gap (wiring) between the grates is 10 mm, the distance between the grates and the pegs is 25 mm, and the edge (facet) of the grate is 40°, the performance of the machine is a rational indicator of the loosening of karakul wool. The clogging of facets with weeds between the fire grates, as well as adherence of wool locks to the pegs of the peg drum have been eliminated. More than 3% of very coarse wool was recovered from the wool obtained in autumn. Because of effective purification of raw materials from impurities, an ecologically clean product can be obtained. Decontamination of natural harmful waste (utilization) of the primary processing of wool is considered an urgent task.

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