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Justification of parameters of the technical tool for purification of wool in the conditions of shearing points

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Abstract
Theoretical justifications and results of a pilot study, the analysis of some parameters of the small-sized device for cleansing of high weeded wool are given in article.

Keywords: Animal husbandry, rough wool, high weeded wool, a weed filter, a working gap, rollers, distance between rollers, saw, fibers, subbunker sieves

Introduction

In the Republic of Uzbekistan sheep breeding is one of primary branches of animal husbandry. Today in the farms of the republic specialized on animal husbandry over 30 thousand tons of rough wool are made.

Therefore the purpose of researches are reasons for parameters of the technical tool allowing to increase quality of cleansing of wool, a labor productivity and to cut energy expenses.

The woolen fibers processed now at the textile entities have a considerable contamination. Content of mineral impurity in rough wool reaches 5%, residual fat - to 2, 5%, and burdock- to 8-9%. Use of similar fibers in case of production of nonwoven fabric (felt) or a yarn perhaps only in case of their effective cleaning in tribal department, and then by the combing machines having special mechanisms and devices for these purposes.

Attempts of textile workers to cleaning wool special aerodynamic devices or its freezing and then crushing budrock have not led to desirable result.

Insufficiently removed from wool to a burdock, other vegetable impurity and other impregnations firmly linked to woolen fibers litter a saw part of combing machines and, passing from a drum to a drum, grows blunt and outwears an expensive combing font, reducing its service life by 30-45%. As a result – quality of process worsens considerably, broken the evenness of a semi-finished product causing not evenness and stratification of felt or not evenness of a yarn leading to essential increase in a discontinuity of a yarn and decrease in consumer properties of fabrics.

So far various methods of cleansing of woolen fibers of impurity and defects before combing transition did not provide necessary indicators. Therefore on a number of factories process of carbonization of fibers and fabrics was used. However this process of carbonization breaks ecology, reduces durability of fibers and fabrics in case of considerable finance costs.

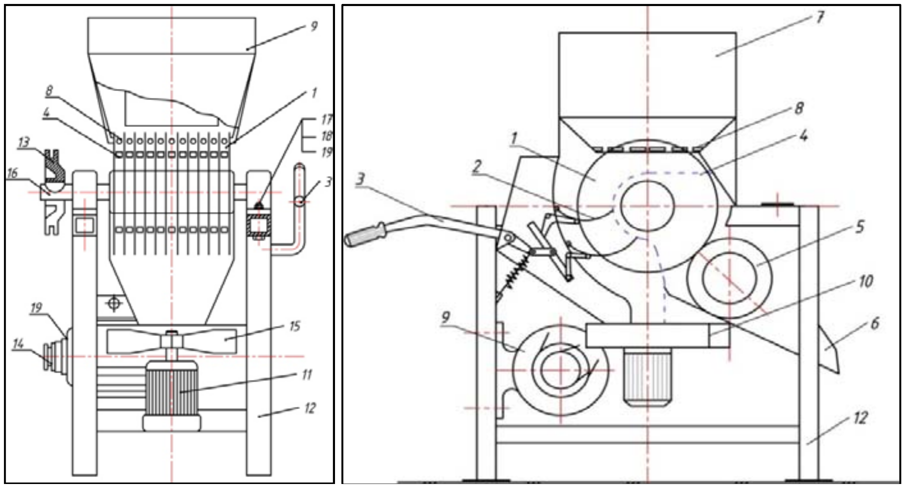
In world practice in process of increase in a contamination of the wool arriving for conversion, cleaning of burdock were carried out on perhaps thin layer of fibrous material by ever-increasing number of working bodies of textile machines.

One of the most negative factors of cleansing of wool is shortening of fibers, for example, on the cleaning machines, and insufficient removal small weed and litter.

Therefore, questions of enhancement of technologies of cleaning and primary conversion of wool and technical means for their implementation are actual.

Materials and methods

The device of cleansing of high weeded wool developed by us during operation allows to delete large litter effectively.
The modern design of a node of cleansing of wool for three years was enhanced and now the node is in our opinion brought to the optimum design allowing to provide to 90-95% cleansing of wool of impurity and defects.
The small-sized device for cleansing of strongly weeded wool (fig. 1) has a simple design and is simple in use.



1-saw drum; 2- weed filter, 3- handle; 4- limiter; 5-brush drum; 6 - windows for removal of wool; 7 - bunker; 8-subbunker sieve; 9 - electric motor; 10 - the ventilating fan; 11- electric motor of the fan; 12- frame; 13 - pulley of a saw drum; 14 - pulley of the electric motor; 15- blade of the fan; 16 - shaft of a saw drum; 17- nut of M10; 18 - washer engraving; 19 - bolt of M10.

Fig 1: The constructive diagram of the device for cleaning of wool.

Process of cleaning is executed in the following order: the polluted wool boots in the bunker 7, from the bunker clings teeths of a saw drum 1 and goes to the working camera of cleaning (fig. 1).
The camera of cleaning is equipped by two weed filter (fig. 2) having fingers. The distance between fingers on the first weed filter makes 4 mm, on the second 6 mm. When the saw drum is rotated between fingers burdocks are delayed on a spherical surface of a weed filter. Then cleared wool is removed from teeths of a saw drum brushes of a brush drum of 5 (fig. 3).

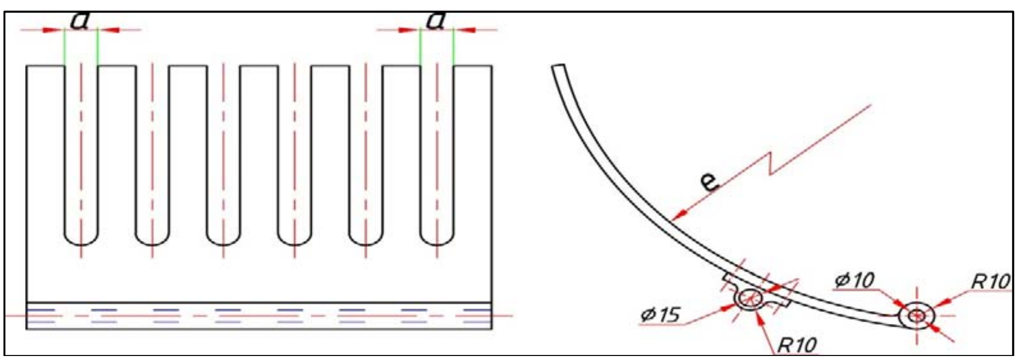


Fig 2: Constructive scheme of a weed filter

Technical parameters of the device for cleansing of wool

- the required power, kW … … … … … … … … … … 1, 5
- number of service personnel, persons … … … … … … 1
- overall dimensions:
 length, mm … … … … … … … … … … … … ... … 1400
 width, mm … … … … … … … … … ... … … … …. 850
 height, mm … … … … … … … … … … … … … ... 1200
- diameter of a saw drum, mm … … … … … … … … 320
- diameter of a brush drum, mm … … … … … … … 220
- nominal frequency of rotation of a saw drum, mines-1 … … 120
- nominal frequency of rotation of a brush drum, mines-1 ….250
- constructive mass of the device, kg … … … … ... … 96

Thus, using of the small-sized device for cleansing of high weeded wool in the conditions of shearing points allows to increase the volume of the prepared wool, improves the subsequent process of cleaning and is additional incentive to stabilization of a financial position of livestock farms.
For the purpose of determination of power parameters (device productivity, a torque and frequency of rotation of a saw drum, quality of the cleaned wool, preservation of length of fibers, extent of cleaning) samples of hair of sheep of different degree of a contamination have been prepared. Prepared for experiences, littered with sticky seeds and the remains of various plants, wool has been selected on degree of humidity and length of fibers. Results of selection are given in table 1.

Humidity of wool, %	Wool fiber length, mm	Contamination degree, %	Fibre fineness, mkm
1-group			
16-17	130-150	10-15	28,4 – 33,3
2-group			
20-25	100-120	15-20	26,7 – 31,1
3-group			
25-30	50-100	20-30	24,4 – 26,0

According to TSt 63.03:2001 "Tests of agricultural machinery. Methods of a power assessment" indicators of work of experimental installation, were defined by the strain-measuring device

- Measurement of a torque on a shaft of a saw drum and its frequency of rotation. A breaking of fibers of wool was defined by calculation of the appeared gaps from among the processed weight, numbers of the broken-off fiber - as a percentage to fiber length before processing;
- Extent of cleaning was defined by calculation of the remained litter (as a percentage) in relation to the maximum number of litter before processing;
- Angular speed of a saw and brush drum was measured on each option, the angular speed of a saw drum is regulated by change of diameters of pulleys;
- The rational corner of a weed filter was defined by measurement of extent of cleaning and ruptures of fibers of wool at his various provisions.

On experiments the device productivity, a torque and frequency of rotation of a saw drum, quality of the cleaned wool, preservation of length of fibers, extent of cleaning on the example of wool of various groups have been determined (tab.1). When determining these indicators GM-0,4 and TsS devices – 53A (the device for determination of length of fibers), Lanometr (the device for definition tannins of fibers) GPOSh-2 (a hydraulic press), analytical scales, by TsS-1531 a drying cabinet, the thermometer have been used (for control of temperature of a drying cabinet).

Measurement of a torque was carried out by means of the sensor of the torque consisting of 8 sensors KF 5P1-10-200 pasted by glue like "Tsiakrin" on a shaft. Tensoresistors are placed on a shaft site between a pulley and its first support (fig. 3).

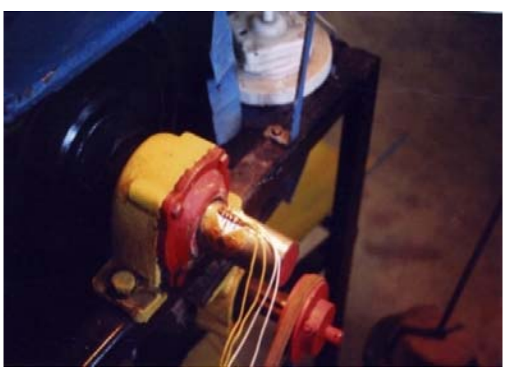


Fig 3: Measurement of torques of a shaft of a saw drum

For measurement of frequency of rotation of a shaft of a saw drum, the sensor consisting of the magneto-operated contact (sealed-contact) and two magnets fixed on a pulley has been used (fig. 4.). A sealed-contact has been soldered by contact of the reciprocal socket of a connecting cable which was fixed on the same arm, as slip ring. The EMA-P small-sized equipment has been used to registration of measuring information from sensors of a torque and frequency of rotation (SP 153).

Fig 4: Measurement of frequency of rotation of a shaft of a saw drum

The equipment provides average values of the measured sizes with the choice of time of registration 7, 5; 15; 30; 60; 120 and 240 pages. The equipment has undergone testing of working capacity by means of TK-22 strain gauging.

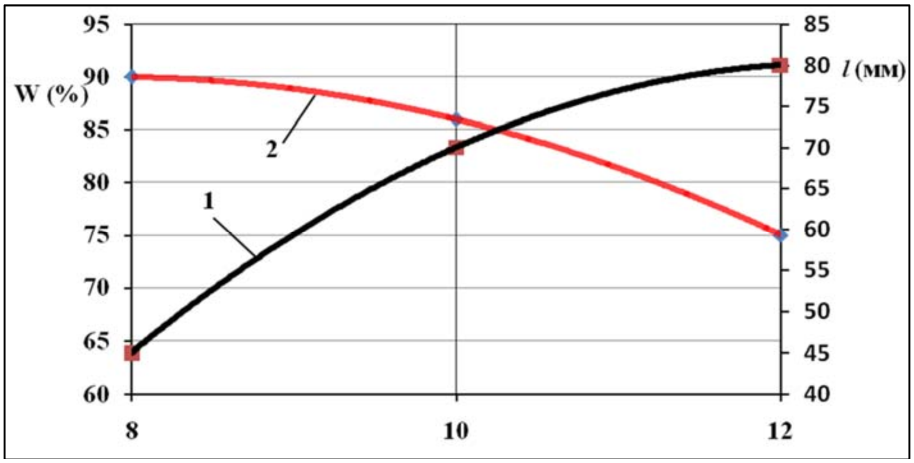
Proceeding from results of theoretical researches, tests were carried out at the following values of sizes: distance between rollers of a subbunker sieve 8, 10, 12 mm, the frequency of rotation of the saw reel 90 … 200 min^{-1} the angles of installation of soroulovitel of rather saw reel 30º … 60º.

As the main indicators at control of the purified wool extent of her cleaning and preservation of length of fibers were accepted. Therefore arithmetic-mean values of the remains of sticky seeds of plants and length of fibers of the purified wool were defined.

Results of tests are given in table 2. From the table it is visible that reduction of distance between rollers improves quality of cleaning, however ruptures of fibers of wool increase.

Indicators	Distance between rollers of subbunker sieves, mm		
	8	10	12
Extent of purification of wool, W (%)	90-95	85-90	70-80
Fiber length after cleaning *l*, (mm)	40-50	65-70	70-75

Results of pilot studies show that at the minimum values of distances between rollers of a subbunker sieve extent of purification of wool increases to (90-95%). However at the same time the number of gaps, lengths of fibers leading to reduction to 45 mm at the same time grows. Results of experiments are visually presented in fig. 10.



Distance between rollers, L (mm)
1 – lengths of fiber after cleaning; 2 – extent of cleaning.

Fig 5: Influence of distance between rollers of a subbunker sieve on quality of cleansing of wool W and at length fiber, at ω=120 min^{-1}, W = 17%, β = 45 °

Reduction of length of fibers of wool reduces quality of the made materials. From the analysis of schedules it is visible that value of distances between rollers of a subbunker sieve at 10 mm is considered rational. At the same time purification of wool more than 85% is provided at preservation of length of fiber not less than 70 mm.

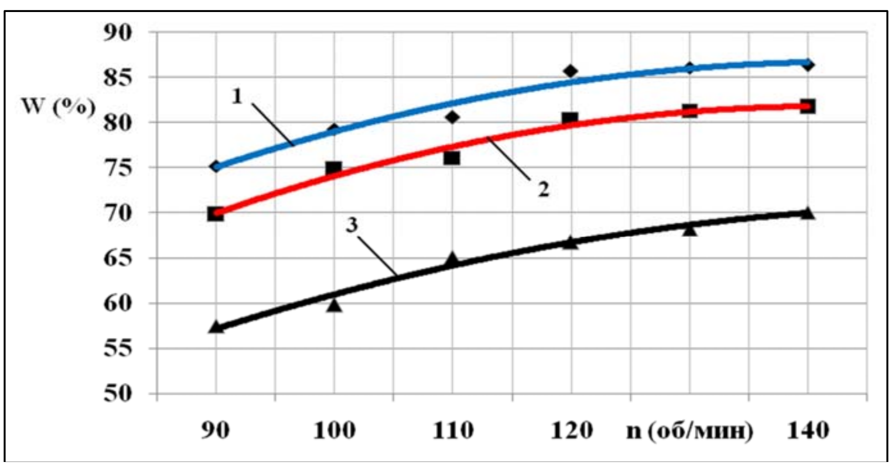
As we know, wool substance hygroscopic. At increase in humidity of wool of fibers tensile strength decreases.

For the choice of optimum humidity of wool comparative pilot studies at humidity of Wvl of.=10-12%, Wvl of.=16-17%, Wvl of.=19-20% at triple frequency are conducted.

At the same time the following parameters are accepted: the distance between rollers of 10 mm, the angular speed of a saw drum is 90-140 min^{-1}.

The assessment of quality of the purified wool was carried out on extent of cleaning and length of fibers. Results of tests are given in fig. 6.

From fig. it is visible that humidity and angular speed of a saw drum exerts considerable impact on extent of purification of wool. Increase of humidity leads to difficulty of office of sticky impurity and respectively to decline in quality of the purified wool. Speed exerts almost linear impact on extent of cleaning.



1 humidity of 17%; 2 humidity of 20%, 3 humidity of 25%.

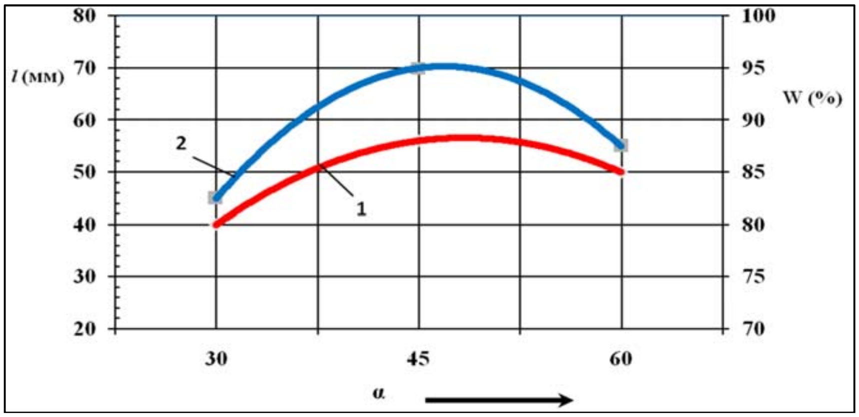
Fig 9: Influence of humidity of wool and angular speed of a saw drum on extent of cleansing of wool.

At increase in n till 120 min.-1 extent of cleaning improves approximately for 10%.

For example, at humidity of Wvl of=17%, n = 90 min. -1W=60-65%, at n = 90 min.-1 W.=80-82%, and at n = 120 min.-1 already W=85-87%. At other values of humidity similar decrease is observed. After n = 120 min^{-1}, W change not considerably, doesn't exceed 3 … 5%.

Proceeding from it rational Wvl can accept.=17%.

For definition of influence of a corner between a saw drum and a weed filter the following parameters have been accepted. The angles of installation of a weed filter changed within 30 … 600 (fig. 10), at the same time the speed of rotation of a saw drum was 120 rpm, the distance between rollers of a subbunker sieve made 10 mm. Results of the conducted researches are given in fig. 7



1– extents of purification of wool, 2 – length of fibers after wool processing

Fig 7: Influence of a corner between a weed filter and a saw drum on quality of wool.

Results of the analysis of data from fig. 7. Show that increase in a corner of a weed filter from 30 to 450 leads to improvement of quality of wool. For example, at coal 300 extent of cleaning averaged 80-85%, increase in a corner up to the 450th this indicator increases by 10%. At further increase in a corner of a weed filter to 600 there is a wool deterioration at which extent of purification of wool decreases to 85-86%.

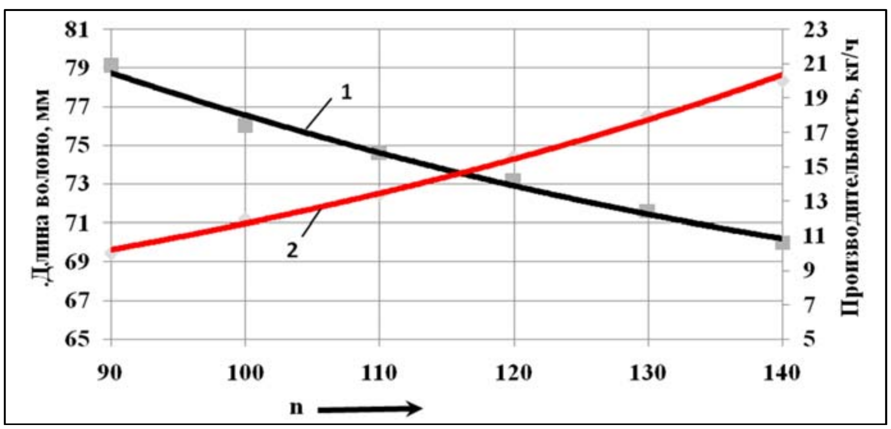
However the choice of an optimum angle α only on extent of purification of wool without a breaking of fibers would be wrong as length of fibers of wool is more important than extent of cleaning.

From the schedule (fig. 7) it is visible that at coal α=300 fiber length after cleaning made the 45-50th, and at the 450th this indicator I have improved for 10-15%. However at increase in a corner to α=600 this indicator I have decreased and I have made the 55-65th which doesn't conform to zootechnical requirements.

Connecting with it as the rational parameter of a corner α 450 are accepted.

For adjustment of frequency of rotation of a saw drum the experimental version of the device of purification of wool is equipped with a 6-staged pulley that allows will receive frequencies of turns of a saw drum from 90 to 200 min^{-1}.

From figure 8. It is visible that with increase in speed of rotation of a saw drum productivity of the device of purification of wool increases, however at the same time also the number of ruptures of fibers considerably grows.



Length of fibers, mm Productivity, kg/h
1 – Extents of purification of wool, 2 – productivity of the device

Fig 8: Influence of angular speeds (ω) a saw drum on quality (on fiber length) cleansing of wool

At an angular speed of 130-140 min.-1 productivity of work increases almost twice in comparison of n=90 min^{-1}. However with increase in speed of a saw drum the rupture of fibers increases on 15, 7 … 20, 5%, than at an angular speed of 120 min^{-1}.

It can be explained with the fact that at high angular speed there is a clogging of quarrel between rollers and between fingers of a weed filter, it leads to a breaking of fibers. For example, at n=140 mines-1 length of fibers after processing has made ℓ =45-50 mm. At an angular speed of 118-120 min^{-1} these indicators improves, for example length of fiber has made ℓ=65-70 mm. Proceeding from it the most optimum can accept n = 120 min^{-1}.

The most power-intensive knot of the device is the saw drum, a sub bunker sieve. Therefore definition of influence of their parameters on power consumption is very important. This dependence is determined by an experiment planning method. On the basis of the previous researches intervals of a variation of factors of X_1 – the angular speed of a saw drum (ω), by rpm, X_2 – the angle of installation of a weed filter (α) a hail, X_3 – distance between fingers of a weed filter (a), mm and X_4 – distance between rollers of a sub bunker sieve (v), mm are specified.

The torque (μR), extent of cleaning (W) and length of fiber (l) are taken for criterion of optimization.

The major studied factors, intervals and levels of their variation are presented in table 3.

Table 3: Intervals of a variation and levels of factors

Factors and their size	Symbol of factors	Variation intervals	Levels of factors		
			Lower (-1)	Main (0)	Higher (+1)
Angular speed of a saw drum, min-1	X_1	55	90	145	200
Angle of installation of a weed filter,° (degrees)	X_2	15	30	45	60
Distance between fingers of a weed filter, mm	X_3	2	4	6	8
Distance between rollers of a subbunker sieve, mm	X_4	2	8	10	12

For carrying out calculations the planning matrix according to the plan of Boks-Benkena V4 has been made.

Calculations of coefficients of regression are executed on the computer by means of the Excel program. Check of a hypothesis of adequacy to the received model was made by Fischer's F-criterion.

After processing of results of experiments and an assessment of the importance of coefficients the following equations of regression which are adequately describing technological process of cleaning are received:

change of a torque (kN.m)

$$M_{kp} = 19,2 - 1,34X_1 - 1,89X_2 - 1,23X_3 - 1,19X_4 + 0,08X_1X_2 - 0,51X_1X_3 + 1,48X_1X_4 - 0,27X_2X_4 - 0,40X_2X_4 + 0,20X_3X_4 + 1,48X_1^2 + 16,4X_2^2 + 15,2X_3^2 + 14,4X_4^2$$

Degree of a cleanliness of wool, %

$$W = 82,7 - 0,3X_1 + 3,1X_2 + 1,08X_3 + 0,86X_4 - 0,33X_1X_2 - 0,62X_1X_3 + 0,37X_1X_4 + 0,29X_2X_3 - 0,45X_2X_4 - 0,04X_3X_4 + 85,9X_1^2 + 86,3X_2^2 + 86,1X_3^2 + 86,4X_4^2$$

length of fiber, mm

$$L = 64.73 - 4.75X_1 + 7,61X_2 + 8,89X_3 + 8,15X_4 - 1,65X_1X_2 - 1,7X_1X_3 - 1,16X_1X_4 + 1,033X_2X_3 + 0,983X_2X_4 - 1,07X_3X_4 + 93,28X_1^2 + 91X_2^2 + 95,54X_3^2 + 93,52X_4^2$$

The analysis of the regression equations indicates that all parameters of the device influence quality of purification of wool, but factors of X_2 and X_3 have a greater influence, and one torque more than all factors X_2 factor influences, and renders a factor of X_3 and X_4 on length of fibers, influence of other factors several times is less, but insignificant have influence.

After carrying out optimization the method of penal functions has received the following rational N=1, 5 parameters of kW, M =22,3kn.m.

Conclusions

1. At mechanical cleaning humidity of fibers of wool shouldn't exceed 16-17%, in opposite cases the rupture of fibers sharply increases and extent of cleaning decreases.
2. By comparative studying of various types of the device of cleansing of wool it is established that the drum has to have saw working body which promotes gearings of fibers and normalize supply of wool from the device bunker.
3. Pilot studies are established by rational parameters of the device of cleansing of strongly weeded wool are: diameter of a saw drum is D=0,320 m; the rational angle of installation of a weed filter - 45 °; number of a saw of npl of =10 pieces; power consumption – 1,5 kW; angular speed of a saw drum ω=120 min^{-1}; angular speed of a brush drum is-250 min^{-1}; distance between rollers of a subbunker sieve - 10 mm.
4. By pilot studies it is established that cleansing of strongly weeded wool in conditions the of the farm increases volume of wool. The received products meets on the requirement to the primary wool.
5. By primary wool cleaning by using this device extent of cleaning reaches W=90-95%, and lengths of fibers of wool L = 60-70th.
6. At mechanical cleaning the type and degree of impurity of wool doesn't influence strongly to quality of processed wool.

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