Analysis of research on fiber waste processing technology and its improvement

Mukhammad-Bobur Abdulbokievich Karimov
Fayzullo Khusanboy-ogli Rakhimov
f.rahimov95@mail.ru
Rustam Muradovich Muradov
muradovrustam340@gmail.com
Namangan State Technical University

Abstract: *This article presents technological machines for processing fiber waste generated during the primary processing of cotton, their operating principles, advantages, and disadvantages. It also analyzes the designs of new fiber waste processing machines proposed as a result of scientific research conducted by scientists to improve existing technological machines.*
Keywords: *cotton, fiber, fiber waste, staple length, sliver, regeneration, mineral additives, organic additives, textiles, light industry, raw materials*

Introduction

In our country, large-scale measures are being taken to develop the cotton industry, and research is being conducted to introduce new technologies into the industry and their practical application. The new Development Strategy of Uzbekistan for 2022-2026 sets objectives, including “Continuing industrial policy aimed at ensuring national economic stability and increasing the share of industry in the gross domestic product, as well as increasing industrial production by 1.4 times” [1]. One of the urgent tasks of manufacturing enterprises is the efficient and timely recycling of waste generated during the primary processing of cotton raw materials at ginning plants, separating fibrous products from their composition, and preventing their release into the environment.

Materials and Methods

During the primary processing of cotton, after appropriate treatment for the textile and light industries, fibrous waste containing a large amount of fibrous material is separated from production and transport equipment. The characteristics of this waste are presented in Table 1.

Table 1

Characteristics of fibrous waste

Waste sorting machines	The outcrops	Description of waste
All types of gins and fiber clarifiers, ginning seed clarifiers used up to the first linter, fiber condensers, regenerators treating fiber waste.	Fibrous waste	This includes stunted diseased seedlings (cobs), adjacent fiber, free fibers, fibrous waste, various weeds and mineral mixtures (dust, sand, soil).
Lint condenser cyclones, seed cleaners placed before the second and third linters	Short cotton wool	Fibers shorter than 3 mm, mixed with dust and fine dirt.

The waste generated in the cotton gin during the initial processing is divided into 3 types.

1. Gross mixed waste.
2. Cotton mixed waste.

3. Down waste.

Gross mixed waste is a mass consisting of fibrous parts, core and impurities discharged from the gin, seed cleaner and fiber regenerator. The appearance of gross mixed waste is checked by comparing the combined sample with the appearance sample. Waste mixed with cotton lint is collected by cyclones from the lint condensers and aspiration system. It includes short fibers, impurities and dust mixture remaining after lint regeneration from the fiber mass [2].

The gap between the gin bars is of a specified size, and the gin bar is adjusted as necessary, and the amount of gin-spun cotton separated from the gin depends on the type of cotton being processed. When processing first and second grade cotton, 0.2-0.3% of the cotton weight is separated, and when processing third and fourth grade cotton, 0.5-0.6%, and in some cases 1.5% [3]. If the gap between the gin bars is wider than the specified size, large seeds may also be mixed with the waste. Depending on the type of cotton, fiber content, dirtiness, moisture content and color, the fiber gin is divided into 2 types and must comply with the requirements given in Table 2.

Table 2.

Properties of fiber

№	Indicator name	Types	
		1	2
1	The color of the total mass	From white to light brown	New color
2	Maximum content of pure fiber, %	40	
3	Pollution base norm	14	
4	Basis moisture relative to absolute dry mass, %	10	
5	Unripe seeds, empty seeds, unripe seed pods	Not standardized	

Regenerated fiber is obtained by reprocessing type I and II fiber slivers in a special regenerator machine. Such fiber contains a large amount of impurities and a large amount of impurities. In addition, the fiber staple is not uniform, has many short fibers, and the staple length is 2-6 mm shorter than that of cotton fiber of the same type. The fiber obtained from regeneration is divided into two types depending on its toughness, and its properties must comply with the requirements given in Table

Table 3.

Standard indicators of fiber obtained from regeneration.

№	Indicator name	By varieties	
		1	2
1	Breaking force, N	0,039	0,038
2	The sum of defects and the basic norm of impurities, %	10,0	20,0
3	Base norm of moisture relative to absolute dry mass, %	9,0	12,0

In cotton ginning plants, technological machines of various designs are used to process this fibrous waste and the fibrous products obtained from it. This is the OBM brand cleaner, which itself has two different designs. One of them, OBM -1, cleans cotton lint and lint, and OBM -2 cleans the fiber core from impurities continuously during the technological process. OBM -1 and OBM -2 differ from each other in the types of machines and the structure of the drums, the size of the gap between the mesh surface and the drum (Fig. 1).

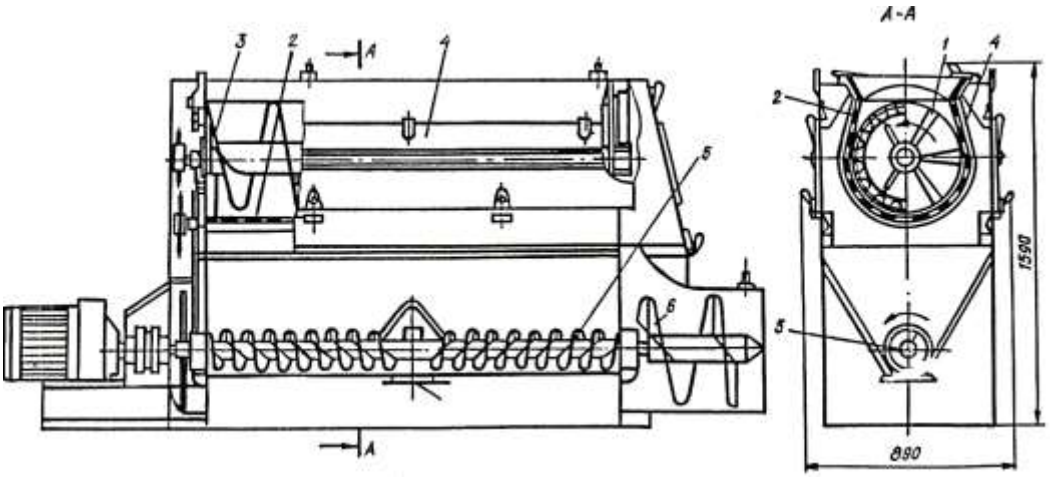

Figure 1. Scheme of the OBM -1 brand cleaner.
1-Pile drum, 2-Mesh surface, 3-Screw agitator, 4-Shoulder, 5-Screw conveyor for removing waste from the machine.

The process of cleaning fibrous waste in OBM cleaning machines is as follows. After the fibrous waste enters the cleaner, it is dragged over the mesh by the rotating drums under the influence of the pegs (or troughs) located on the screw, and the impurities and dust are separated through the mesh. The separated impurities fall into the auger and are removed through the hatch. The cleaned fibrous waste falls into the screw agitator and is slightly compressed and sent to the pressing shop.

Table 3.

Characteristics of OBM -1 and OBM -2 brand cleaners

Car brand	The type of network	Drum type	Gap between the screen and the drum, mm
OBM-1	Diameter 1.5	with stakes	3-7
OBM-2	Wire mesh 3x25 mesh	taster	18-22
OBM-2	8x8 mesh netting made of wire	taster	18-22

The technical description of the OBM brand cleaner is presented in Tables 4.

Table 4

Technical description of OBM -A cleaner

Indicators	OBM-A-1	OBM-A-2
Productivity, kg/h	300	300
Diameter of drums, mm	500	500
Drum rotation frequency, rpm		
Drum type	150	150
Galvir type	piled up	with a saw
Galvir hole size, mm:	perforated	woven
to clean short fluff	1.5	-
for cleaning	-	8x8 H8
for cleaning lint	3,25x3,25	ГОСТ3826-47
The gap between the drum and the roller, mm:		
to clean short fluff	2,8	17-23
for cleaning lint	17-23	-
Cleaning efficiency, %		
for cleaning short fluff	70	-
for cleaning lint	30	-

for cleaning	-	60
Installed power, kW	2,2	2,2

Table 5 lists electric motors, reducers, bearings and belts.

Table 5

List of electric motor, bearings, reducers and belts for OBM -A cleaner kinematic drawing

Name and designation	Number of machine
Electric motor 4AM132M6УПУУз, н=790 hour/minute, П=7,5 кВт	1
Reducer Ц2У-125, 20-32 Уз	1
Bearing 11310	4
Bearing 206	2
belt Б-1800Т	3
belt Б-2240Т	2

To separate fibers suitable for spinning from the fiber sliver, POB (Figure 2) and 2POB (fiber waste regenerator) machines are used (Figure 3). This machine is installed in the waste cleaning shop together with the OBM brand waste cleaning machine [2]. They continuously clean the waste separated by the gin and fiber cleaning machines in the technological process and separate the fibers. The POB machine consists of the following main parts: cleaning section, wire drum section, regeneration section, supply adjustment section, frame and control cabinet.

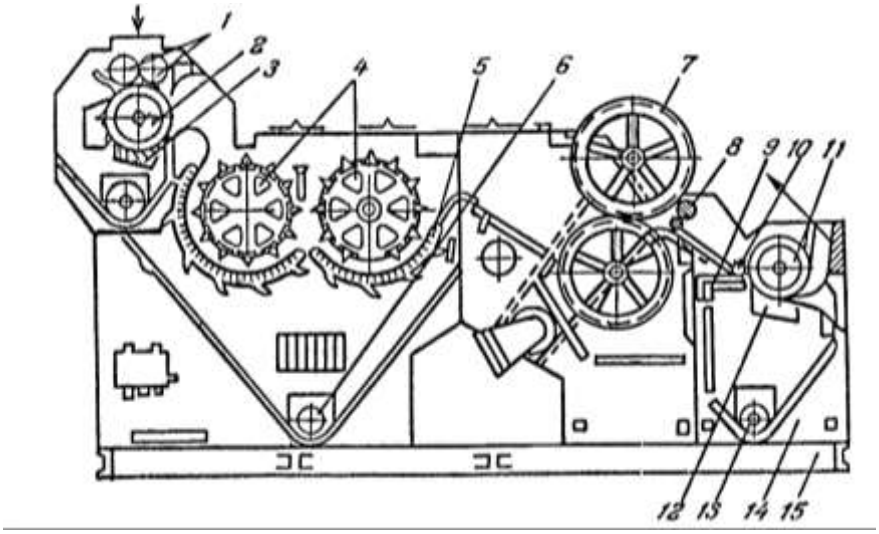

Fig. 2. POB fiber waste regeneration machine

1- cleaning section: grooved feed rollers; 2- saw cylinder; 3- grate; 4-slatted drum; 5-grated grate; 6-sluice screw; 7- grid drums; 8-grated rollers for separating the canvas; 9- feed bed; 10-feed rollers; 11- saw cylinder; 12- grate; 13-special auger; 14-machine body; 15-frame.

The waste caught in the saw begins to hit the grate 3. After several repeated hits on the grate, impurities, grains and large foreign objects in the waste pass through the grate gap and fall onto the impurities conveyor 6. The cleaned fibers are separated from the saw drum under the influence of centrifugal force and are directed towards the pile drums 4. The pile drums additionally clean these fibers by passing them through the slatted grate 5. The separated debris passes through the grate gap and falls onto the impurities conveyor 6. The cleaned fibers are transferred to the mesh drum section 7 [2-3]. The air flow drawn in by the fan adheres the fibers to the mesh drum in a uniform thickness. Rollers 8 separate the layer of fibers adhered to the surface of the mesh drum and transfer them through a chute to the supply roller 10. Since the axis of the supply roller is compressed by springs on both sides, the fibers are also compressed to the seat. The cut fiber layer is transferred to the saw

drum 11. The saw drum combs the fiber layer that has come out from under the roller, carries away the fiber and additionally cleans it through the grate 12. Under the influence of centrifugal force, the fiber is separated from the saw drum and is directed by the air flow to the KB-0.3 condenser. The technical characteristics of the ROV brand fiber waste regeneration machine are given in Table 6.

Table 6.

Technical characteristics of the regenerator

Productivity in relation to the weight of untreated fibrous waste, kg/hour:	
For cotton of grades I and II	100
For cotton of grades III and IV	200
Fiber yield from untreated fibrous waste, %	85
Cleaning effect, %	85...90
Rotational frequency, min^{-1}:	
supply rollers	0…20
saw cylinder in the cleaning section	915
the first peg drum	815
second peg drum	807
reed drums	1,31
separator rollers	11,05
supply roller	12,55
saw cylinder in the regeneration section	1205
log auger	34,4
Power of electric motors, kW:	
moving working bodies in the cleaning department (AOT-62-4; 1465 min^{-1})	7
moving the work bodies in the regeneration department (AOT-4, 1450 min^{-1})	2,8
slow-rotating working bodies mover (AO32- 4, 1410 min^{-1})	1
Overall dimensions, mm:	
tall	4560
width	1760
height	2095
Mass, kg	3885

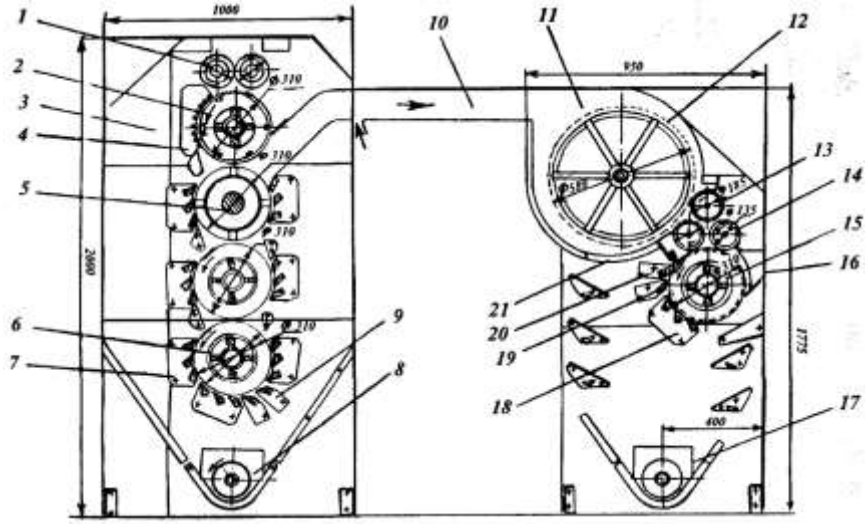

Fig. 3. Drawing of the 2POB fiber regenerator

1 - rollers; 2 - saw drum; 3 - cleaning section; 4 - grate; 5 - knife drum; 6 - saw drum; 7 - grate; 8 - screw dirt conveyor; 9 - double grate; 10 - connecting pipe; 11 - regenerating section; 12 -

corrugated drum; 13, 14, 21 - rollers; 15 - saw drum; 16 - separator; 17 - screw conveyor; 18 - grate; 19 - grate; 20 - brush for moving fibers into the furrow.

In cotton ginning plants, fibrous waste is divided into two types as a product, namely, large waste and short lint waste.

The waste separated by fiber cleaners and fiber condensers is cleaned to separate the fibers from its composition. The separated fibers are added to the main cotton. The scheme of cleaning fibrous waste and returning the separated fibers to the main cotton is shown in Figure 1.3.

Table 7

Technical specifications of the 2POB fiber regenerator

Fiber yield from cleaned fiber pulp, % not less	90
Cleaning efficiency, %	60
Labor productivity when processing fiber slag of types I and II, kg/hour	From 250 to 300
Rated capacity, kW	12,7
Including: in the cleaning section in the regeneration section	 7,5 5,2
Power consumption during no-load operation, kW, not more than	5,22
Including: in the cleaning section in the regeneration section	 2,95 2,27
Air flow, m3/s	From 2.28 to 2.68
including: from the drum of the regeneration section for transporting regenerated fiber	 1,7-1,9 0,58-0,78
Technical indicators of the cleaning section:	
Rotational frequency, rpm:	
for the supply roller	0,14
for the bladed drum	97
for saw drum	97
for a dirty auger	50
The gap between the outer surface of the drum and the edge of the column, mm	0,5-3,5
Technical parameters of the regeneration section	
Rotational frequency, rpm:	
for the snare drum	20
for the supply roller	80
for saw drum	420
for a dirty auger	50
Technological slots, mm:	
between the vibrating drum and the separating roller	2-4
between the vibrating drum and the compaction roller	2-8
between the compaction and separation rollers	2-5
таъминлаш валиги билан аррали барабан орасида	0,5-3,5
between the saw drum and the working edge of the grate	0,5-3,5

Analysis of research results

A number of scientific studies have been conducted by researchers to further improve existing technological processes, and a number of positive results have been achieved in the processing of fibrous waste. Researcher B.Aliyev [2] proposed a new design of a drum device with a ЦМПЛ that separates fibers suitable for spinning from fibrous waste (Figure 4).

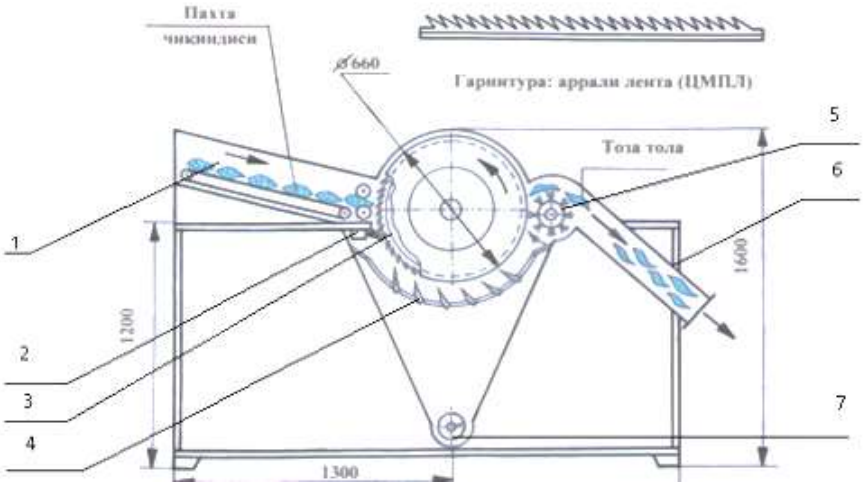

Fig. 4. Scheme of the cotton waste separation device proposed by B.Aliyev
1-inlet pipe, 2-guide, 3-drum with ЦМПЛ, 4-knives, 5-drum with brushes, 6-outlet pipe, 7-outlet pipe for short fibers.

This device works as follows: waste enters through the inlet pipe 1 and through the sieve 2 it enters the needle drum 3, and long fibers are caught by the drum needles and, due to their rotation, hit the grids 4, enter the brush drum and are removed from the needles by the brush drum 5, and the fibers are removed through the outlet pipe 6.

M.Sultanov [3] developed a device for separating cotton fibers suitable for spinning, the main working part of which is a needle drum (Fig. 5).

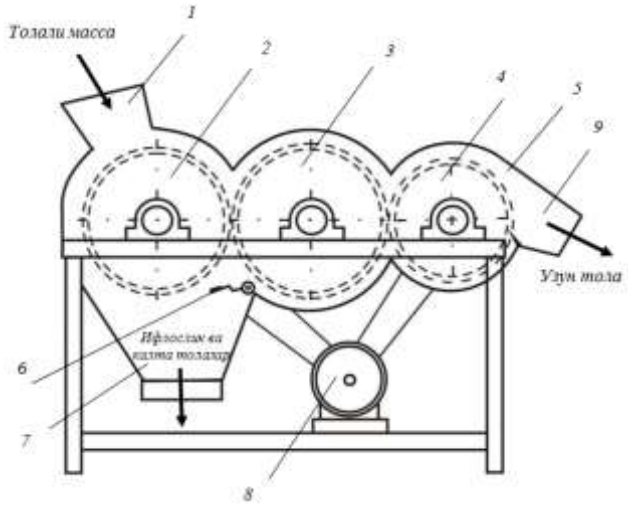

Fig. 5. A device for separating cotton fiber suitable for spinning, developed by A.Sultanov.
1-inlet pipe, 2-needle receiving drum, 3-main needle drum, 4-brush drum for removing long fibers, 5-jacket, 6-guide for long fibers, 7-shaft for short fibers,
8-electric motor, 9-shaft for long fibers.

This device works as follows: the fluffy mass coming out of the linter through the inlet pipe 1 enters the needle receiving drum 2, where the fibrous mass is attached to the drum for shaking and the shaking process begins, and it is additionally shaken using the shakers installed on the side (not visible in the figure). Then the collected fibrous mass enters the needle main drum 3, and the long fibers in

the mass are caught and removed by the side needles of the main drum [5]. The short fibers and other impurities remaining in the receiving drum 2 fall down and are discharged out of the short fiber shaft 7. In order to increase the accuracy of catching the long fibers, a guide 6 is installed on the lower wall of the needle main drum 3, with the help of which long fibers are directed to the main drum. The long fibers caught in the main drum 3 are subsequently removed by the brush drum 4 and discharged out of the long fiber shaft 9.

A.Mirzaakbarov [4-5] also developed a device with an innovative design that separates fibers suitable for spinning from fibrous waste as a result of its processing (Figure 6), for which a patent certificate for the invention was also obtained from the Intellectual Property Center of the Republic of Uzbekistan (IAP 7635).

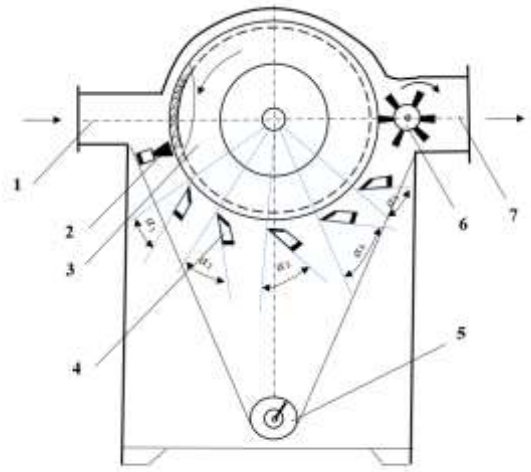

Figure 6. A device for separating cotton fiber from waste.
1 - inlet pipe, 2 - guide, 3 - saw drum, 4 - rollers, 5 - screw, 6 - brush drum, 7 - outlet pipe.

The method of separating fibers from cotton waste begins with the introduction of waste into the equipment through the inlet pipe (1) through the guide, and the waste is directed towards the saw cylinder (3) (with a bevel angle of the teeth of the saw discs $\gamma=60^{0}$ and a tooth pitch t=3.59 mm, height h=3.46 mm). The saw teeth are held by a brush drum (6). The saw cylinder carries the waste between the rollers (4) at high speed. Cotton fibers are separated from the waste between the grates and the teeth of the saw disk. The bevel angle of the first grate is $\alpha1=30^{0}$, the second is $\alpha2=35^{0}$, the third is $\alpha3=40^{0}$, the fourth is $\alpha4=45^{0}$, and the fifth is $\alpha5=50^{0}$. The separated fibers are directed to the outside through the outlet pipe (7) of the device. The unusable waste separated from the grates is directed to the bottom of the equipment through a brush drum, which, in turn, is removed through a waste discharge screw (5) [6].

Conclusions

Based on the above analysis, it is possible to reduce the consumption of raw materials at enterprises by improving the existing process and technological machines for processing waste and separating fibers from them, and redesigning them in accordance with modern requirements. As a result of research conducted by researchers on the improvement of existing devices, positive results were obtained that complement each other [6]. Further improvement of this work is possible, taking into account that the cleaning of fibrous waste from both mineral and organic impurities in one device affects the efficiency of the process, and if the cleaning process from mineral impurities is carried out at a distance from the main cleaning and separation units of the device for this process, the cleaning efficiency of the device can be further increased.

References

1. International cotton advisory committee, Washington, From the Secretariat of the ICAC, https://icac,org/, email secretariat@icac,org, September 1, 2018.
2. Б.Алиев “Пахта чиқиндилари таркибидаги йигирувга яроқли толаларни ажратиб олувчи қурилмани такомиллаштириш”. Диссертация. Техника фанлари бўйича фалсафа доктори. Наманган 2020 й.
3. М.Султонов Диссертация. Техника фанлари бўйича фалсафа доктори. Наманган 2020 й.
4. А.Мирзаакбаров “Толаларни чиқиндилар таркибидан ажратиб олувчи қурилманинг самарадорлигини ошириш” Тақдимнома. Диссертация ҳимоясисиз ихтиро патенти асосида техника фанлари бўйича фалсафа доктори илмий даражасини бериш бўйича. Наманган 2024 й.
5. F.Rahimov, N. Gadaev, Kh. Kosimov, R. Muradov Theoretical Studies on the Impact of Cotton and Heavy Mixtures on the Walls of the Working Chamber of the Stone Crusher // Web of Semantic Universial Journal on innovative Education, Volume 2 Issue 3, Year 2023 ISSN: 2835-3048 https://univerpubl.com/index.php/semantic.
6. Kh.M.Khuramova, Kh.Isakhanov, Rustamjon Muradov, Fayzullo Raximov Changes in energy consumption during extraction of cotton pieces in an improved regenerator. AIP Conf. Proc. 3304, 030030 (2025) https://doi.org/10.1063/5.0269104. 22 July 2025 04:36:30. 030030-1- 030030-6 p.