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Evaluation of Mechanical Prototype Machines for Continuous Separation of Respirable Cotton Dust Fractions

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The original cotton particulates analyzer used stationary screens to separate aerodynamically the coarse and fine dust fractions from small samples of cotton. By replacing stationary with rotary screens that were continuously cleaned, larger supplies of respirable dust were obtained without interruption. A ginned and a waste cotton were used to test two methods of separation: a rotating 38-μm screen and a tandem rotating 710- or 38- μm screen and cyclone. The fine dust fractions from both systems were captured on filters and examined gravimetrically, by Coulter counter, and scanning electron microscope. The dust passing 38 μm stationary or rotary screens contained particles of 15 μm maximum diameter whereas dust from the 710-gmm rotary screen and tandem cyclone exhibited particles of 10 μm maximum diameter and lint fragments. Dust fractions with particles less than 10 μm diameter and free of lint were obtained with a 38-μm rotary screen and tandem cyclone.

Introduction

The amount of dust in ginned cotton is a matter of health-related interest because of particulates released from cotton during processing. In earlier reports (*1–3*) the design and operation of a cotton particulates analyzer (CPA) was described. Mechanical opening and air suction were used to separate ginned cotton aerodynamically into fractions of lint, trash, and dust that were captured without material loss (Fig. 1). Lint and dust were drawn to the outer surface of a perforated rotary drum, cleaned lint was removed from the drum surface by an auxiliary vacuum nozzle, and the dust was drawn through the drum. The dust was separated by and captured on three stationary screens and an absolute, final filter. The CPA design, however, allowed only 15-g samples of cotton to be processed.

The need to gather respirable dust fractions in large quantities for a variety of tests has led to modifications of the CPA to provide for continuous separation of dust from a supply of ginned or waste cotton. The modified CPA could also be used to supply low levels of respirable dust continuously to an animal exposure chamber. The current study had three objectives: to compare dust fractions from ginned cotton that passed stationary (the old CPA) and rotary (the new CPA) 38-μm screens; to evaluate three methods of separating respirable dust fractions from the whole supply of material in which a rotary 38 μm screen and a tandem rotary 710- or 38-μm screen and cyclone are used; and to compare dust fractions from a ginned cotton with dust fractions from waste cotton.

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Experimental

Analysis of the CPA cotton dust fractions reported earlier (*1,3*) showed that a stationary 710-μm screen eliminated lint longer than 9.5 mm (3/8 in.) from the dust fractions and 38 μm screen passed lint-free dust particles

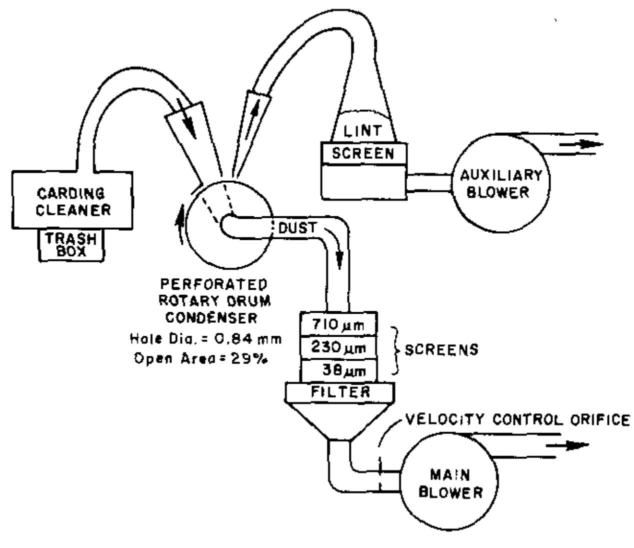

FIGURE 1. Schematic diagram of the old CPA.

below 30 μm. Dust that lay on the 38 μm screen consisted exclusively of only 200 μm diameter particles and fiber fragments 200 to 1000 μm long. In the current study, 710- and 38-μm screens were used consecutively on a rotary drum with and without a tandem cyclone to provide dust fractions with different particle sizes.

CPA Modifications

In the present CPA design, (Fig. 2), the ginned cotton was opened by a carding cleaner (4) that applied a draft between a slow-turning feed roll and a high-speed doffer roll. The loosened, heavy trash fell into a collection box; lint, light trash, and dust propelled by the airstream generated by the doffer passed to the outer surface of a rotary drum covered with either a 38- or 710-μm screen. The material that passed the screen was captured by a polypropylene filter which retained all particles as small as 0.5 μm; the material that remained on the surface of the rotary screen was removed by an auxilary vacuum nozzle raised 6.4 mm (0.25 in.) above the screen.

In a subsequent design (Fig. 3a), the lint, light trash, and dust arrive at the surface of the drum covered with either a 710- or 38-μm screen. The material that remained on the surface of the rotary screen was removed by auxiliary suction. The material that passes either screen went through a cyclone (Aero-Cyclone centrifugal dust collector, General Resources Corp., Hopkins, MN) that was designed to remove approximately 90% of the particulates greater than 10 μm diameter. Design airflow rates through the cyclone were between 204 and 85 m^3/hr (120–50 cfm). A final filter of polypropylene captured all dust as small as 0.5 μm.

When the 38-μm rotary screen was used for dust removal from waste cotton, a secondary vacuum brush in contact with the screen was placed immediately behind the auxiliary vacuum nozzle. The vacuum brush had a 101.6 mm (4 in.) outside diameter with 25.4 mm (1.0 in.)

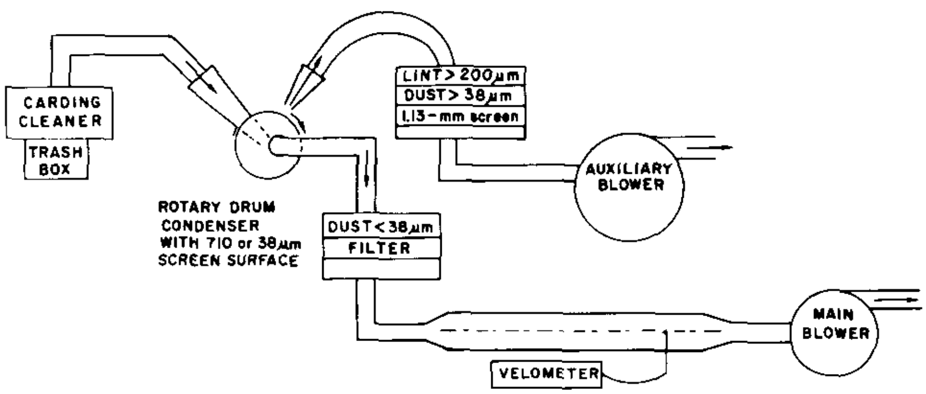

FIGURE 2. Schematic diagram of the new CPA with 710- or 38-μm rotary screen surface.

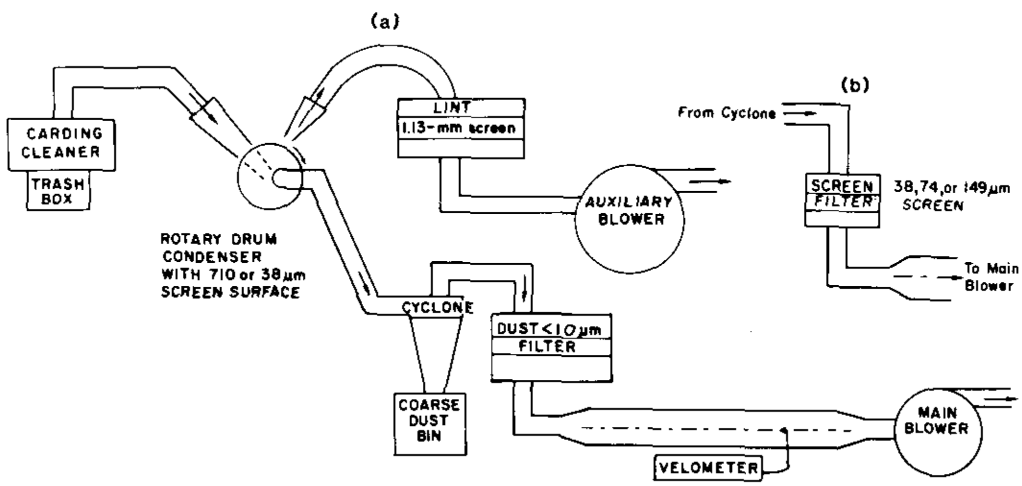

FIGURE 3. Schematic diagram (a) of the new CPA with 710- or 38-μm rotary screen and tandem cyclone and (b) tandem stationary screen and filter that replaced filter of CPA shown in Figure 2a.

long bristles and was hollow. Suction was provided to the brush handle by a commercial vacuum cleaner through a 38.1 mm (1.5 in.) diameter flexible tube. The brush was moved back and forth during the tests to remove particles of dust that could not pass the screen.

The feed roll of the CPA opener-cleaner was operated at 0.0314 rad/sec (0.3 rpm) and the doffer roll at 356 rad/sec (3400 rpm). These speeds are 60% slower and 70% faster than the respective rolls in the old opener-cleaner. The spacing between the same rolls was 0.203 mm (0.008 in.) and 0.254 mm (0.011 in.) for the new and old machines, respectively. These changes were made to increase the amount of dust removed from the cotton.

The new CPA rotary drum had a diameter of 305 mm (12 in.) and a length of 444.5 mm (17.5 in.) which was rotated at 4.19 rad/sec (40 rpm). The drum surface was made of 70 gauge, flatened, expanded stainless steel with a 70% open area. A nylon screen with either a 710- or 38-μm square mesh opening was placed over the support surface and fixed with a 5 min epoxy cement.

Procedures

The new CPA was compared with the old CPA by gravimetric measurements of the dust fractions that passed 710- and 38-μm screens and the trash fractions from one ginned cotton. Particle size distributions of the dust fractions that passed 38-μm screens in the new and old CPA machines were compared.

Additional gravimetric and particle size tests of the new CPA were made: a waste cotton was used to evaluate the dust fraction that passed a 38-μm rotary screen and the same ginned and waste cottons were used to evaluate dust fractions that passed the tandem array of a 710-μm rotary screen and cyclone and a 38-μm rotary screen and cyclone.

All experiments were conducted in a room under ambient conditions; the range of temperature was 23.9 to 27.8°C (75–82°F) and relative humidity 60 to 90%. All samples before and after a test were conditioned overnight in a conditioned room at 23.9 ± 1°C (75 ± 2°F) and 55 ± 2% RH. Sample weights were either 15 or 30 g. All samples were processed at the rate of 15 g/4 min through the CPA. All tests were replicated two to nine times.

An Alnor Type 8500 Thermo-Anemometer Velometer was used to measure the center-line velocity in a 152.4 mm (6 in.) diameter duct from which the mean rate B of airflow through the system was determined by the equation:

$$R = 0.9\, Vd^2\pi/4$$

where V is the center-line velocity and d is the diameter.

Auxiliary tests on the cotton dust fractions included Coulter counter analysis and scanning electron microscopy. Filter subsamples were taken with cylindrical brass disc cutters with diameters of 15.9 mm (5/8 in.) and 12.7 mm (1/2 in.). Thibodeaux's procedure (*6*) was used for extraction of dust from the filter with ultra-sonic washing in methanol, filtration through a 38 μm sieve, and analyses by a model TAII multichannel Coulter counter. Discs of polypropylene filter material containing the dust were mounted for scanning microscopy by pressing 13 mm diameter sample studs faced with double-coated cellophane tape to the back surface of the filter. The immobilized sample was coated with a thin layer of gold palladium by vacuum evaporation (*7*).

Materials

A high-trash ginned cotton, that had been used in the ASTM interlaboratory Shirley analyzer test (*8*) and again in the early CPA (*1,3*) development, was used for instrumental comparison. A supply of cotton trash, Code Name 1182 DB, supplied by Cotton Inc. and consisting of short fibers, leaf fragments, and dust and known to be byssinotically active was used as a source of dust.

Results and Discussion

Test of 710- and 38-μm Rotary Screens in the CPA

Samples of ginned and waste cotton (15 or 30 g) were used in the new CPA and passed through a rotary screen of either 710 or 38 μm (Fig. 2). The dust and trash fractions produced were compared with dust and trash fractions from a previous study (*3*) for the same cotton in which the 710- and 38-μm screens were stationary. Mean

Table 1. Comparison of weight fractions of dust and trash from ginned cotton captured on filters used in new and old models of the CPA.

	Dust that passed screen				Trash	
	710 μm rotary[a]	710 μm stationary[b]	38 μm rotary[a]	38 μm stationary[c]	New CPA	Old CPA
Mean weight, mg/kg	12,917[d]	15,818	3813[d]	1280	44,390[e]	47,627
σ_x	±1966	±1195	±592	±55	±2970	±2871
n	5	5	5	5	5	5

[a] New CPA. Screen cleaned by auxiliary vacuum nozzle and sample weights = 30 g.
[b] Old CPA. Screen cleaned by brush and sample weights = 15 g.
[c] Old CPA. Screen not cleaned; low weight of dust trapped on screen did not effect dust that passed through.
[d] Student's t test; like dust fractions of new and old CPA were significantly different at the 95% level of confidence.
[e] Student's t test; trash fractions of new and old CPA were not significantly different at the 95% level of confidence.

weights of dust and trash fractions captured after passage through rotary or stationary screen are listed in Table 1. The rotary 710-μm screen produced 18% less dust and the rotary 38-μm screen produced 298% more dust than the respective stationary screens of the old machine. The trash weight fractions of the new CPA were not significantly different from that of the old CPA (95% level). Therefore, the increased fine-dust fraction of the new system must have come from the coarse dust and the fiber fractions, and can be attributed to the smaller spacing between the feed and doffer rolls and larger difference in speed between the same rolls of the new machine.

The fibers act as a source of dust: when broken, dust is produced from within and from its own cell walls; fine dust adhering to the surface is liberated by frictional, bending, and torsional forces as the fibers move over one another. We have shown (*3*) that after one cleaning pass through the old CPA, the fine dust remaining on the ginned cotton fibers is equal to the weight of the fine dust fraction liberated on the first pass.

Test of Methods for Cleaning the 38 μm Rotary Screen

Previous work (*1,3*) with ginned cottons and the old CPA used an auxilary vacuum nozzle that was raised about 6.35 mm (0.25 in.) above a rotary, perforated metal drum with hole diameters of 0.85 mm (0.033 in.) and 29% open area. The raised nozzle was sufficient to remove the material (largely lint and lint fragments) from the surface of the rotary drum. A similar nozzle was also used to clean the rotary 38-mm screen of the new CPA, (Fig. 1). The particle size analysis of the dust fractions from the old and new models of the CPA were obtained from the same ginned cotton, (Table 2). The dust that passed through the 38-μm rotary screen had the same particle size distribution as that processed through the perforated metal drum and 710-, 230-, and 38-μm tandem stationary screens of the old CPA. The raised vacuum nozzle, therefore, can be used for processing ginned cottons with the 38 μm rotary screen of the new CPA.

Table 2. Comparison of ginned cotton dust fractions obtained from the old and new models of the CPA.

CPA model	Particle size[a] Mean diameter $\pm \sigma_{\bar{X}}$, μm	Median diameter $\pm \sigma_{\bar{X}}$, μm	% by volume less than 15 μm diameter $\pm \sigma_{\bar{X}}$
Old	3.62 ± 0.28	7.12 ± 1.03	81.5 ± 3.9
New	3.88 ± 0.23	7.65 ± 0.71	80.3 ± 1.1

[a] Coulter counter data, $n = 2$.

The large differences between dust mean and median diameters and percent by volume of the particles less than 15 μm diameter for the ginned and waste cottons indicate that the Coulter-determined distributions are skewed to favor small size particles. The harsher treatment of the ginned cotton by the new CPA, which breaks fibers into smaller pieces and causes more fine dust to be released than that of the old CPA, produces the identical particle size dust distribution to that of the old CPA. No particles, however, greater than 28.5 μm passed the rotary screen as determined from the complete Coulter data.

The weight fractions of trash from the opener-cleaner and the weight fractions and particle size analyses of the dust that passed through a 38 μm rotary screen subjected to auxiliary vacuum and also vacuum brush cleaning were obtained from waste cotton, (Table 3). When only the auxiliary vacuum nozzle was used to clean the 38-μm rotary screen, the rotary screen turned a brownish color which indicated a build-up of large dust particles. In subsequent tests, a secondary vacuum brush in contact with the rotary screen was moved across the screen immediately behind the auxiliary vacuum nozzle in order to remove dust particles trapped on the screen. The weight of the dust from the waste cotton that passed the 38-μm rotary screen with brushing increased 163% when compared with the dust captured without secondary brushing and was 23 times larger than the dust load from the ginned cotton that passed the 38-μm rotary screen (Table 1). A comparison of Coulter data for the waste cotton tests when the filtering coarse dust layer on the 38-μm screen was removed by the vacuum brush showed no differences in mean and median particle diameters or decrease in the percent by volume of the particles less than 15 μm diameter. The distributions are also skewed to favor small size particles.

Table 3. Effect of rotary screen cleaning methods on waste cotton dust fractions.

Method of cleaning 38 μm screen	Mean weight of trash $\pm \sigma_{\bar{X}}$, mg/kg[a]	Mean weight of dust on filter $\pm \sigma_{\bar{X}}$, mg/kg	Particle size[b] Mean diameter $\pm \sigma_{\bar{X}}$, μm	Median diameter $\pm \sigma_{\bar{X}}$, μm	% by volume less than 15 μm diameter $\pm \sigma_{\bar{X}}$
Auxiliary vacuum	73,730 ± 6,733[c]	53,953 ± 4,967[d]	3.80 ± 0.22[c]	6.23 ± 0.37[c]	90.0 ± 1.4[c]
Auxiliary vacuum + vacuum brush	70,750 ± 7,947[c]	88,090 ± 6,127[d]	3.60 ± 0.98[c]	5.75 ± 0.98[c]	89.1 ± 4.2[c]

[a] $n = 4$, 15 g samples.
[b] Coulter counter data, $n = 2$.
[c] Student's t test; columnar values not significantly different at the 95% level of confidence.
[d] Student's t test; columnar values significantly different at the 95% level of confidence.

Test of 710 μm Rotary Screen and Cyclone in the New CPA

Samples of ginned cotton were used in the new CPA and passed through a 710-μm rotary screen and tandem cyclone (Fig. 2*a*) to produce dust fractions with particles less than 10 μm. The mean weight of dust captured was 1800 ± 313 mg/kg. The cyclone-separated fine-dust weight fraction represents 15.2% of the total amount of dust and large lint fragments that passed the 710-μm screen and 47% of the dust that passed the 38 μm screen. represents 24.1% of the dust that passed the vacuum-brushed 38-μm rotary screen (Table 3).

A comparison of electron micrographs (Fig. 4) of dust from waste cotton captured on a filter after passage through a 38 μm screen and a tandem 710-μm screen and cyclone shows that few large fiber fragments have passed through the 38-μm screen, but many long fiber fragments pass through the cyclone. The fiber fragments exhibit aerodynamic characteristics similar to particles of less than 10 μm diameter although their size and weight are many times larger.

Table 4. Dust fractions from waste cotton captured on a filter after passing through a 710-μm rotary screen and cyclone and airflow rates through system.

Sample no.	Airflow rate, am^3/hr[a]	Weight of dust on filters (sample wt = 15 g), mg/kg	Sample no.	Airflow rate, am^3/hr	Weight of dust on filters (sample wt = 30 g), mg/kg
1A	131.6	16,267	1B	86.2	22,267
2A	119.9	21,133	2B	124.3	14,667
3A	111.0	22,933	3B	102.3	15,037
4A	111.0	27,667	4B	107.6	22,600
			5B	81.9	28,267
Mean $\bar{X}$		22,005	Mean $\bar{X}$		20,567
$n = 4, \sigma_{\bar{X}}$		± 4,712[b]	$n = 5, \sigma_{\bar{X}}$		± 5,739[b]

[a] After dust deposition.
[b] Student's t test; not significantly different at the 95% level of confidence. When $n = 9$, $\bar{X} = 21{,}204$ and $\sigma_{\bar{X}} = \pm\ 5{,}036$.

The waste cotton dust was passed through a 710-μm rotary screen and tandem cyclone (Fig. 3*a*) before capture on a final filter. If the filter were overloaded with dust, the airflow rate through the cyclone could be reduced below the minimum rate for efficient removal of large dust particles greater than 10 μm. Dust fractions and airflow rates at the end of dust deposition were determined (Table 4). The different dust weight fractions are presented in units of milligrams/kilogram. No significant differences between dust weight fractions from 15 g and 30 g samples are found at the 95% level of confidence. Although the airflow rates vary widely, the results suggest that the cyclone is functioning as designed because the minimum airflow rates at the end of each test were greater than or approximately equal to the minimum airflow rate 85 am^3/hr (50 scfm) that is required for removal of 90% of the particles greater than 10 μm. The cyclone-separated fine-dust weight fraction

Table 5. Separation of lint fragments from dust of cotton waste after passage of material through 710-μm rotary screen and cyclone and subsequent capture on a screen and final filter.

Screen size above filter, μm	Weight of dust and/or lint fragments[a]: On screen, mg/kg	On filter, mg/kg[b]
38	13,667[c]	4,533
74	5,667[d]	8,933
149	2,833[e]	13,900

[a] Original sample weight = 30 g.
[b] Dust with small amount of lint fragments.
[c] Mixture of dust and lint fragments.
[d] Mixture of lint fragments with reduced amount of dust.
[e] Large amount of lint fragments with small amount of dust; % lint ≈ [2833/(2833 + 13,900)] × 100 = 16.9%.

In order to estimate the amount of lint fragments that pass through the cyclone, stationary screens of 38, 74, and 149 μm were individually placed in front of a 203.2 mm (8 in.) diameter filter (Fig. 2*b*) that replaced the final filter shown in Figure 2*a*. The weight fractions on each of the screens and their corresponding filter fractions are shown in Table 5. With increased screen size, more dust passes to the filter and less remains on the screen. Most of the material on the 149-μm screen, 17% by weight of the total material that passed the cyclone, are fiber fragments.

The Coulter counter analysis of dust particles captured on the filter after passing through a 710-μm rotary screen and cyclone, shows that for the waste cotton, 97% of the particles are under 10 μm diameter (Table 6). The ginned cotton, with only 1/20 of the load of dust of the waste cotton, has 15% of the particles by volume greater than 10 μm diameter. The mean and median particle and volume sizes for the trash and ginned cottons are similar.

Test of 38 μm Rotary Screen and Cyclone in the New CPA

The weight fractions of dust that passed the 38-μm rotary screen and tandem cyclone are listed with the combined lint and dust weight fractions that passed the 710-μm rotary screen and tandem cyclone for the ginned and waste cottons, (Table 7). For the ginned cotton, the weight of the material that passed the 710-μm screen-cyclone combination was 38% larger than the dust that passed the 38-μm screen-cyclone combination. This difference represents the fiber fragment in the 710-μm screen-cyclone sample. These fragments are attributed to the violent tearing action of the opener-cleaner that was observed in our previous work (*3*) and is larger in the new CPA (Table 1).

The fiber fragments in the waste cotton carried over by the cyclone after passage through the 710-μm screen is, by contrast, only 12.9% larger by weight than the dust obtained from the tandem array of 38 μm rotary screen and cyclone. The difference in weight is not statistically different at the 95% level of confidence and is caused by the large standard deviation in the data of the tandem 710-μm rotary screen and cyclone for the waste cotton. A large standard deviation indicates that the fiber fraction passing through the 710-μm screen-cyclone CPA varied widely from sample to sample. If the standard deviation of the same data were as small as that of the 38-μm screen-cyclone CPA data, the 12.9% difference in dust weight between the data of the two CPA systems would be statistically significant at the 95% level of confidence.

It is noted that the 12.9% difference—that represents

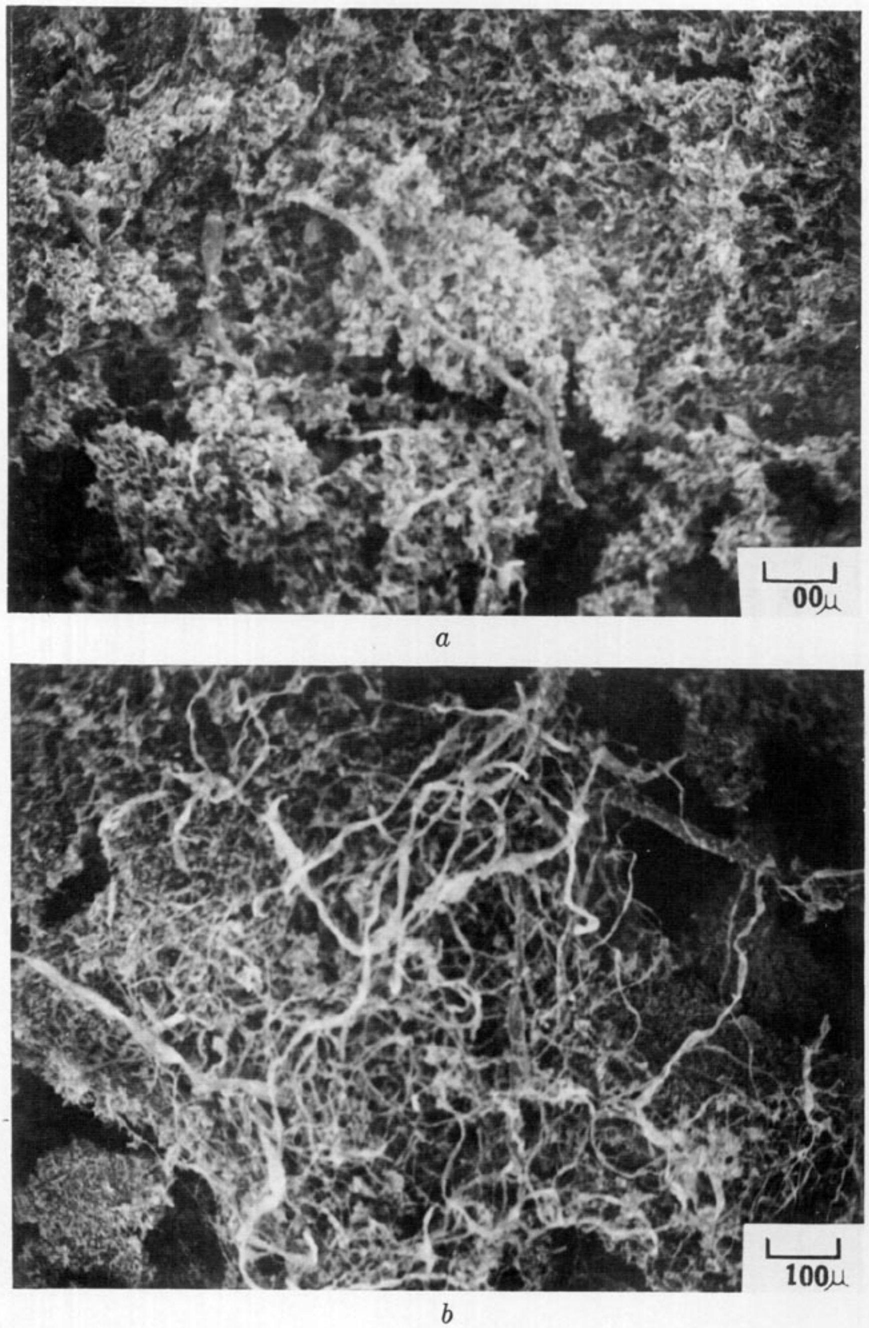

FIGURE 4. Electron micrographs comparing dust fractions from cotton trash captured on filters after passage through (*a*) 38-μm screen and (*b*) a tandem array of 710-μm screen and cyclone.

the level of lint in the dust for the waste cotton—is of the same order of magnitude as the amount of lint (16.9%) measured directly and independently, (Table 5). Thus, the waste cotton has fewer fiber fragments than the ginned cotton in the range under 9.5 mm (3/8 in.) length. The small amount of fiber fragments in the waste cotton is attributed to the gentle action of the commercial opening machine and/or card.

The size of the dust particles that passed the 38-μm rotary screen and tandem cyclone is compared with the size of the dust particles that passed the 710-μm rotary screen and tandem cyclone for both the ginned and waste cottons, Table 8. For each cotton, the mean and median particle sizes and the percent by volume of the particles less than 10 μm from the 38-μm screen-cyclone CPA have about the same magnitude as the respective particle sizes from the 710-μm screen-rotary cyclone CPA. These small differences indicate that little dust is removed from the fibers present in the 710-μm screen-cyclone CPA by Coulter analysis where dust on the fibers is in the 1 to 30 μm range (*3*) and therefore, most of the dust on the fibers has been removed from the ginned and waste cottons after one pass through the new CPA.

A comparison of dust fractions obtained from the 38-

Table 6. Weight fractions and particle size analysis of dust captured on a filter after passage through a 710 μm rotary screeen and tandem cyclone.

Cotton	Sample weight, g	Mean weight of dust on filter ± $\sigma_{\bar{X}}$, mg/kg	Particle size[a] Mean diameter ± $\sigma_{\bar{X}}$, μm	Median diameter ± $\sigma_{\bar{X}}$, μm	% volume less than 10 μm diameter ± $\sigma_{\bar{X}}$
Ginned	15	1,800 ± 313[b]	2.74 ± 0.04[c]	3.92 ± 0.09	84.9 ± 1.4
Waste	15 or 30	21,204 ± 5,036[d]	2.80 ± 0.85[e]	3.82 ± 0.17	96.6 ± 1.5

[a] Coulter counter data.
[b] $n = 4$.
[c] $n = 2$.
[d] From Table 3, $n = 9$.
[e] $n = 7$.

Table 7. Comparison of weight fractions of dust from ginned and waste cottons captured on filters after passage through 38-μm rotary screen and tandem cyclone and 710-μm rotary screen and tandem cyclone.

Cotton	Statistical data	38 μm rotary screen + tandem cyclone	710 μm rotary screen + tandem cyclone	Difference, %
Ginned	Mean weight, mg/kg	1,108	1,800[a]	− 38.4[b]
	$\sigma_{\bar{X}}$	± 230	± 313	
	n	4	4	
	Sample weight, g	30	15	
Waste	Mean weight, mg/kg	18,467	21,204[a]	− 12.9[c]
	$\sigma_{\bar{X}}$	± 2,002	± 5,036	
	n	4	9	
	Sample weight, g	15	15	

[a] From Table 6.
[b] Student's t test; significantly different at 95% level of confidence.
[c] Student's t test; not significantly different at 95% level of confidence.

Table 8. Comparison of particle sizes of dust from ginned and waste cottons captured on filters after passage through 38-μm rotary screen and tandem cyclone and 710-μm rotary screen and tandem cyclone.

		Particle size[a]					
		Ginned cotton			Waste cotton		
CPA system	Statistical data	Mean, μm	Median, μm	% by volume less than 10 μm diameter	Mean, μm	Median, μm	% by volume less than 10 μm diameter
710-μ rotary screen + tandem cyclone[b]	$\bar{X}$	2.76[b]	3.93[d]	85.0[d]	2.91[d]	3.92[d]	97.1[d]
	$\sigma_{\bar{X}}$	± 0.04	± 0.09	± 0.6	± 0.01	± 0.12	± 0.2
	n	2			2		
38-μm rotary[c] screen + tandem cyclone[c]	$\bar{X}$	2.65[c,e]	3.76[d,f]	87.0[d,g]	2.80[d,e]	3.82[d,f]	96.6[d,h]
	$\sigma_{\bar{X}}$	± 0.02	± 0.08	± 2.6	± 0.85	± 0.17	± 1.5
	n	3			7		

[a] Coulter counter data.
[b-c,g-h] Significantly different at the 95% level of confidence (Student's t-test).
[d,e,f] Columnar (d) and row (e and f) values are not significantly different at the 95% level of confidence.

μm rotary screen-cyclone CPA show that both cottons have the same mean and median diameters; the waste cotton, however, has more particles smaller than 10 μm diameter.

The mean and median particles sizes of the 38-μm screen and tandem cyclone-separated dust fractions from the ginned and waste cottons are about 71 and 54% smaller, respectively, than the mean and median particles sizes of the dust fractions that passed a 38-μm rotary screen (Tables 2 and 3). The 38-μm rotary screen samples have about 80 and 90% of the particles less than 15 μm (Tables 2 and 3); the 38-μm screen and tandem cyclone have 86 and 97% of the particles less than 10 μm (Table 8) and about 29 and 21% of the dust weight that passes the 38-μm rotary screen (Tables 1,3 and 7) for the ginned and waste cottons, respectively.

The CPA as a Continuous Dust Generator

The different CPA machines shown in Figures 2 and 3 could be used to generate cotton dust continuously if the dust filter were removed, a baghouse filter installed upstream of the blower, and a large lint chamber added. These modifications would permit large collections of respirable dust. If an animal exposure chamber were also added before the baghouse filter, continuous exposure, i.e., 8 hr/day, of the animals to a constant rate of respirable dust could be achieved.

The dust concentrations in the air stream for the 38-μm rotary screen and the tandem 38-μm rotary screen and cyclone for both the ginned and waste cottons are listed in Table 9. The data were developed from the experimental conditions and results presented in this report where 15-g samples are processed in 4 min. The dust concentrations in the air from the 38-μm rotary screen CPA is 4.6 mg/m^3 and 106 mg/m^3 for the ginned and waste cottons, respectively. The dust concentrations in the air from the tandem 38-μm rotary screen and cyclone are about 1/3 and 1/4 those obtained from the 38-μm screen only for the ginned and waste cottons, respectively.

The dust concentration allowed by OSHA for cotton mills is 0.2 mg/m^3 (*9*). The dust concentration from the ginned cotton may be too small and that from the waste cotton may be too large for animal exposure. The rate of cotton fed to the CPA systems, however, can be increased or decreased to adjust the dust concentration in the air for the intended purpose. In a similar way, the range of respirable particle size can be altered by the kind of CPA system used.

Table 9. Respirable dust concentrations developed by each CPA rotary filter system for ginned and waste cottons.

System	*Mean rate of air passing through* system, am^3/hr	Cotton	Weight of dust on filter, mg/kg	Dust flow rate, mg/hr[a]	Dust concentration in air, mg/m^{3}[b]
38-μm rotary screen	187.0[c]	Ginned	3,813	855	4.6
		Waste	88,099	19,822	106.0
38-μm rotary screen and tandem cyclone	151.3[d]	Ginned	1,108	249	1.6
		Waste	21,204	4,770	31.5

[a] Dust flow rate = (weight of dust) (rate of sample processed) = (0.015 kg/4 min) (60 min/hr).
[b] Dust concentration in air = (dust flow rate) (air flow rate).
[c] $\sigma_{\bar{x}} = \pm 1.5$, $n = 4$.
[d] $\sigma_{\bar{x}} = \pm 4.5$, $n = 4$.

Conclusions

A rotary 38-μm screen can replace the stationary 38-μm screen to convert the old CPA to a more efficient dust separation machine. For light dust loads in ginned cotton, a vacuum nozzle placed 6.35 mm above the rotor is sufficient to clean the screen. For heavy dust loads from waste cotton, a brush vacuum nozzle in contact with the screen removes large dust particles.

A cyclone can effectively remove about 90% of the dust greater than 10 μm but the cyclone cannot remove long lint fragments from the fine dust. A 38-μm rotary screen before the cyclone eliminates long fiber fragments from the fine dust.

The CPA trash fraction weight and the particle size distribution of the respirable dust fraction is constant for a wide range of opener roll speeds and spacings. The weight of the respirable dust fraction, however, increases with opener roll speeds and decreased roll spacing.

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Names of companies or commercial products are given solely for the purpose of providing specific information; their mention does not imply recommendation or endorsement by the U.S. Department of Agriculture over others not mentioned.

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