COMPARISON OF THE GOLDENLION CONTAMINATION CLEANER WITH STANDARD SEED COTTON CLEANING MACHINERY

Derek Whitelock
Paul Funk
Carlos Armijo
USDA-ARS Southwestern Cotton Ginning Research Laboratory
Las Cruces, NM
Mathew Pelletier
Greg Holt
John Wanjura
USDA-ARS Cotton Production and Processing Research Unit
Lubbock, TX
Neha Kothari
Vikki Martin
Cotton Incorporated
Cary, NC

Abstract

The Handan Goldenlion Cotton Machinery Co. Contamination Cleaner (GLCC) is a commercial system currently used in China to removed plastic contamination from seed cotton at the cotton gin. The GLCC was tested to compare its performance to that of conventional seed cotton cleaners. Seed cotton "spiked" with pieces of shopping bags, single-layer non-tacky round module wrap (RMW), and three-layer RMW of various sizes was introduced into the machines. Overall, the GLCC was more effective at removing plastic contamination than a conventional cotton gin stick machine and inclined cleaner. Increasing the air flow to the GLCC improved plastic removal. Overall capture of plastic across all sizes and types increased from 13.5 to 50% when air flow was increased from 10,000 to 18,000 cfm. However, seed cotton captured with the plastic also increased from 3 to 75 pounds per bale. Shopping bag material and 1-ply non-tacky RMW (lighter, pliable) were more effectively removed than three-layer RMW (heavier, stiffer). All the machines tested removed about the same amount of cotton trash (~30 pounds per bale).

Introduction

U.S. and international spinners have recently experienced some serious contamination issues with U.S. cotton. Of particular concern are plastic contaminants – plastic trash that collects in cotton fields, black plastic film used as mulch in fields, plastic twine typically used for baling forage crops, and plastic film used for round module wrap (RMW). These contaminants are typically introduced prior to ginning, but mechanical processes at the gin can tear and shred the plastics so that they become more difficult to detect and remove.

A recently developed vision-based technology was shown to be 90% effective at detecting and removing colored plastics at the gin stand (Rutherford and Sweers, 2020). This technology has limitations in that it detects and removes only colored plastics and is deployed late in the ginning system allowing plastics to be introduced into cotton gin machines upstream from the device. Alternative devices that extract plastics regardless of color or transparency and are designed for deployment at the beginning of the ginning process are needed.

The Handan Goldenlion Cotton Machinery Co. Contamination Cleaner (GLCC; fig. 1) was designed to remove plastic contamination from incoming seed cotton through mechanical and pneumatic operations with 75% efficiency (MQYM10A Operation Manual, Handan Goldenlion Cotton Machinery Co., Handan, Hebei, China).

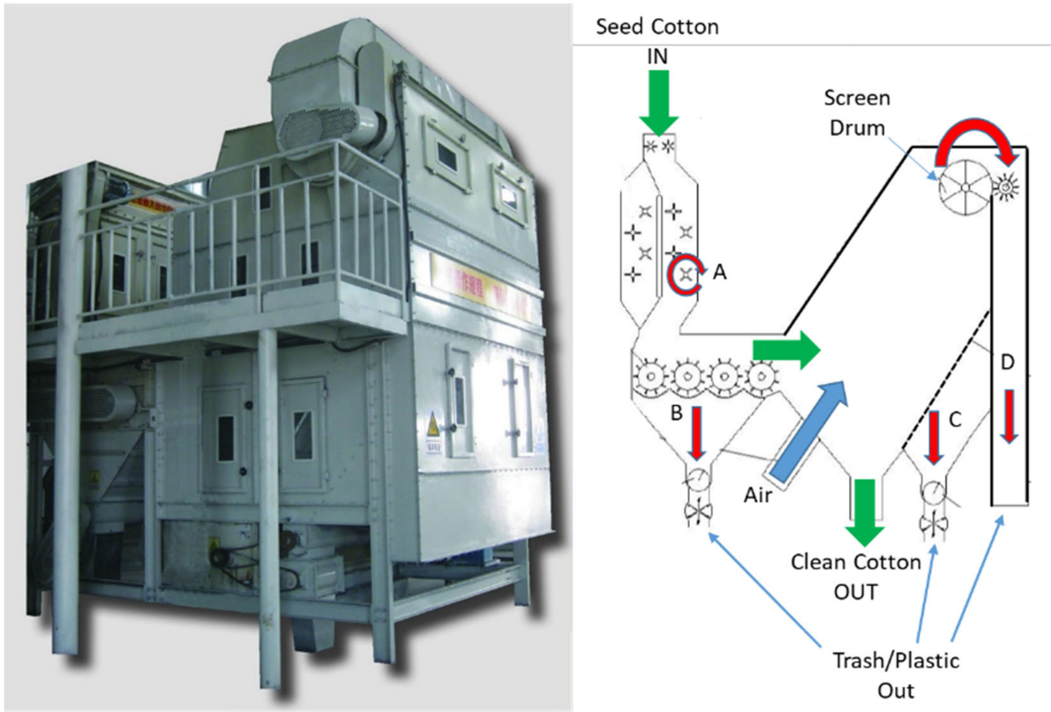

Figure 1. Handan Goldenlion Cotton Machinery Co. Contamination Cleaner (Handan, Hebei, China): A – rotating, spiked cylinders remove strings and large pieces of plastic film; B – rotating, horizontal, spiked cylinders remove small pieces of leaves and foreign matter; C – round bars spaced with gaps in between allow small pieces of leaves and foreign matter to pass and be removed; and D – fine foreign matter and small plastic pieces float with the air flow to the screen drum and are removed to a catchment.

Previous tests of the GLCC showed that airflow rate to the machine had considerable impact on plastic removal performance. Overall, plastic capture increased from 12 to 50% when airflow rate was increased from 8,300 to 17,800 cubic feet per minute (cfm). Pieces of light weight RMW and shopping bags were captured within the range of the manufacturers claims at the highest air flow, but thicker, stiffer RMW was not effectively removed. This increased air flow also increased the amount of seed cotton captured with the plastic from 0.8 to 67 pounds per bale. This may be unacceptable.

The objective of this study was to compare the plastic capture performance of the GLCC to standard cotton gin seed cotton cleaners. This comparative testing will help U.S. gins gauge whether the contamination cleaner could be an effective off-the-shelf tool to use in the fight against cotton plastic contamination.

Materials and Methods

Manufacturer rated capacity of the 8.2-ft wide GLCC was 22,046 pounds of seed cotton per hour. This is equivalent to about 2 bales per hour per foot of width. The stick machine used was a 6-ft wide, 2-saw model and the inclined cleaner was also 6-ft wide with six cylinders (fig. 2)

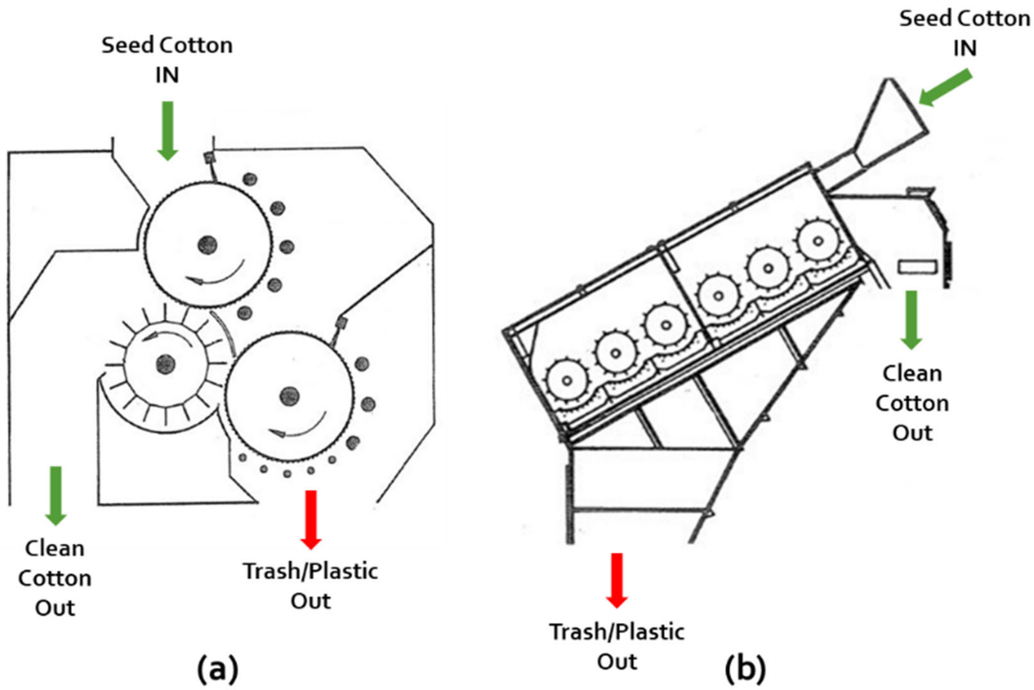

Figure 2: Two-saw stick machine (a) and six-cylinder inclined cleaner (b).

The seed cotton used was NexGen 4545 (https://www.americot.com/product/ng-4545-b2xf/, Americot, Inc., Lubbock, TX). The GLCC was designed to be the first machine that seed cotton entering the gin system will encounter. In the U.S., seed cotton is opened slightly by the module feeder and pneumatic conveyance to the cleaning machinery. For this test, the seed cotton was prepared by opening a round module into a cotton trailer. Then to open the cotton like a module feeder, the raw seed cotton was pneumatically conveying from the trailer via a suction pipe to a 3-cylinder separator before a feed control hopper and deposited in a bin for portioning to weighed lots.

A hopper that holds about 200 pounds of seed cotton was fabricated and installed on the inlet to the GLCC (fig. 3). Two-hundred pounds of seed cotton allowed about 30 seconds of run time. The hopper also incorporated a lid to block air from entering and ensure that air flow did not bypass the appropriate inlets. The seed cotton cleaners were fed 145 pounds of seed cotton for about 30 seconds to achieve the same capacity of 2 bales per hour per foot of width.

Figure 3. The Handan Goldenlion Contamination Cleaner with seed cotton hopper installed at the USDA-ARS Southwestern Cotton Ginning Research Laboratory.

Three airflow rates to the contamination cleaner were used: 10,300, 14,000, and 17,800 cfm. These were obtained by setting a variable frequency drive on the fan providing air flow to the contamination cleaner. The manufacturer recommended maximum airflow rate was between 14,700 and 20,600 cfm. Airflow beyond 17,800 cfm was not achievable due to the high-pressure losses through GLCC at high airflow rates. Also, the earlier tests showed that high airflow rates resulted in excessive removal of clean seed cotton, which was undesirable.

Three types and sizes of typical plastics introduced into ginning systems were used for the test (fig. 4). The types ranging from thin, light, and pliable to thicker, stiffer, and heavier were shopping bags, single-layer (non-tacky inner) RMW (1-ply), and three-layer (tacky, tacky, non-tacky inner) RMW (multi-ply). The sizes were 2 in. x 2 in. (small), 4 in. x 12 in. (medium), and 2 in. x 48 in. RMW or whole shopping bag (large). Before each test run, 20 pieces each of the small and medium plastic samples and 5 of large plastic samples for each type were randomly distributed throughout the seed cotton lot.

Figure 4. Sizes and types of plastic pieces used for testing the contamination cleaner. Types were shopping bags (Red), single-layer (non-tacky inner) RMW (Light Yellow and Light Pink), and three-layer (tacky, tacky, non-tacky inner) RMW (Dark Yellow and Dark Pink). Sizes were 2 in. x 2 in. (small), 4 in. x 12 in. (medium), and 2 in. x 48 in. RMW or whole shopping bag (large).

The GLCC was tested according to the following steps (fig. 5):

1) The “spiked” seed cotton was placed in the hopper.
2) The systems were started, and the airflow rate was set according to the experiment design.
3) The seed cotton was fed at the pre-determined feed rate (2 bales per hour per foot of width) to the machine.
4) The cleaned seed cotton was collected under the machine, and the foreign matter and plastic pieces were collected at the trash/plastic outlets.
5) From each trash/plastic outlet, the trash and seed cotton collected were weighed, and the plastic pieces were separated, sorted by size and type, and counted.

The seed cotton cleaners were tested according to the following steps:

1) The “spiked” seed cotton was placed on the floor at the entrance to a conveying pipe that ran to a seed cotton separator above the seed cotton cleaners (fig. 6).
2) The systems were started (the airflow rate was not varied for the seed cotton cleaner tests).
3) The seed cotton was manually introduced into the pipe entrance at the pre-determined feed rate (2 bales per hour per foot of width).
4) The cleaned seed cotton was collected under the machine, and the foreign matter and plastic pieces were collected at the trash outlets.
5) From the trash/plastic outlet, the trash and seed cotton collected were weighed, and the plastic pieces were separated, sorted by size and type, and counted.

Figure 5. Steps to test the GLCC.

Figure 6. Seed cotton "spiked" with plastic contamination pieces and prepared for manual feeding into the conveying pipe to the cotton gin seed cotton cleaners.

Results

Figure 7 shows the percentage of small (2 in. x 2 in.) pieces of plastic that were removed by the different machines. The GLCC with high air flow removed the most multi-ply RMW (27%) of the three contamination cleaner treatments, but the stick machine removed the most small pieces of multi-ply plastic (38%) overall. For the lighter plastics (1-ply and shopping bag), the GLCC with high air flow removed about twice as much as the other machine treatments (58% and 77%, respectively). The GLCC with low air flow and the cylinder cleaner removed few small plastic pieces.

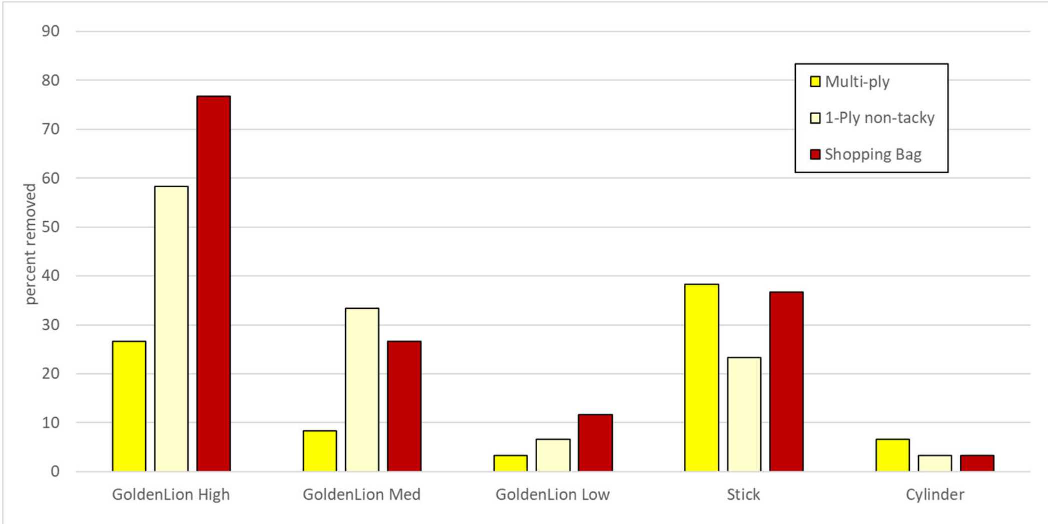

Figure 7. Results for 2 in. x 2 in. plastic contamination pieces removed from the seed cotton by the GLCC (low, medium, and high air flow), stick machine, and cylinder cleaner.

Figure 8 shows the percentage of medium (4 in. x 12 in.) pieces of plastic that were removed by the different machines. The GLCC with high air flow removed the most medium plastic pieces (68%, 52%, and 23% of shopping bag, 1-ply RMW, and multi-ply RMW, respectively. This was more than 1.75 times the plastic removal of the next most effective machine treatment (GLCC with medium air flow). All other machine treatments removed less than 10% of the multi-ply RMW, less than 25% of the 1-ply RMW, and less than 40% of the shopping bag. Also, the stick machine and cylinder cleaner did not remove any of the medium shopping bag pieces.

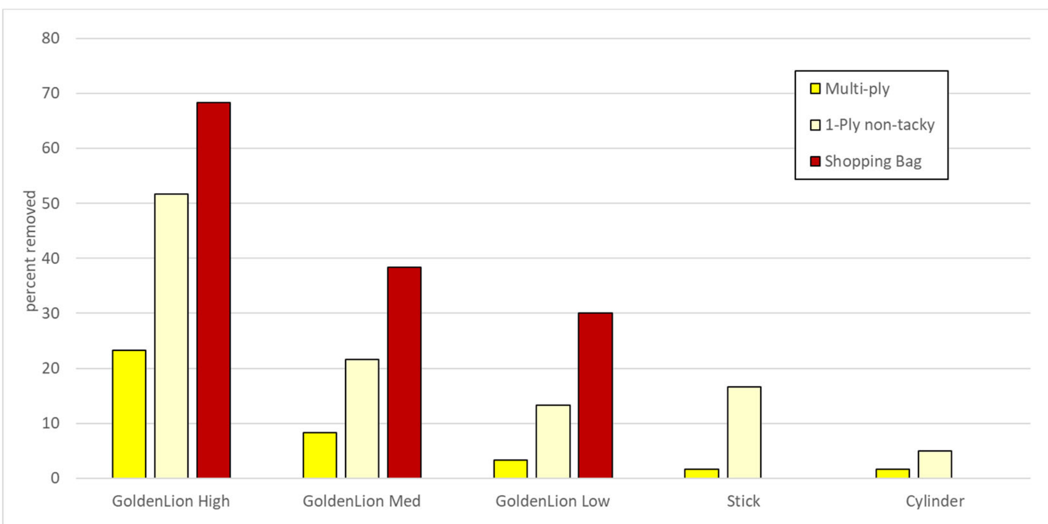

Figure 8. Results for 4 in. x 12 in. plastic contamination pieces removed from the seed cotton by the GLCC (low, medium, and high air flow), stick machine, and cylinder cleaner.

Figure 9 shows the percentage of large (2 in. x 48 in. or whole bag) pieces of plastic that were removed by the different machines. The stick machine and cylinder cleaner did not remove any of the large plastic pieces. The GLCC with high air flow removed the most multi-ply RMW pieces (33%) and whole shopping bags (73%). Unexpectedly, the most 1-ply RMW pieces (47%) were removed by the GLCC with low air flow.

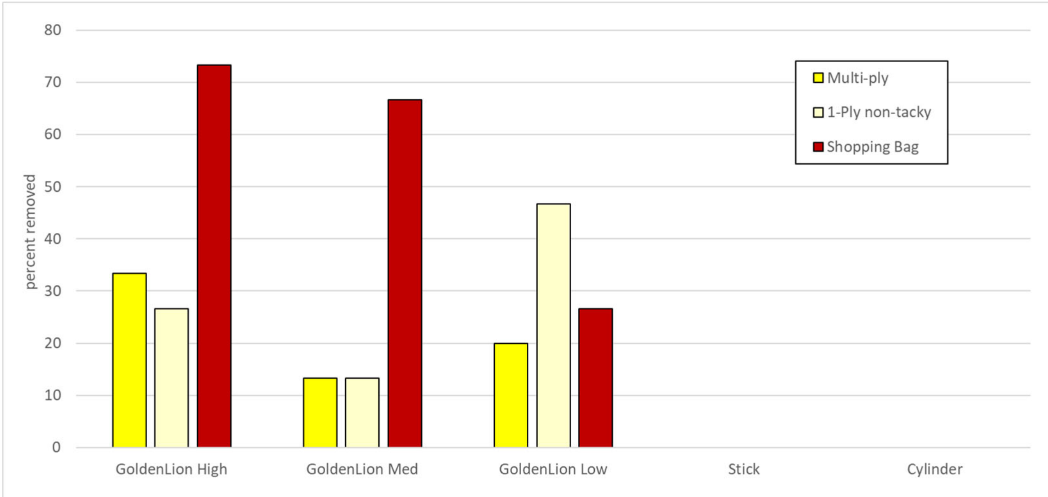

Figure 9. Results for 2 in. x 48 in. RMW or whole shopping bag plastic contamination pieces removed from the seed cotton by the GLCC (low, medium, and high air flow), stick machine, and cylinder cleaner.

Figure 10 shows the percentage of all plastic sizes and types removed, the amount seed cotton captured with the plastic pieces, and the amount of cotton trash removed by the different machines. Overall, the GLCC with high air flow removed about 50% of all the plastic pieces, more than twice as much as the other machines. However, the contamination cleaner with high air flow also captured more than three times the amount of seed cotton with the plastic (75 pounds per bale) than the other machines, which could pose a new challenge for the gin to deal with this mixture of cotton and plastic. All the machines removed about 30 pounds of gin trash per bale.

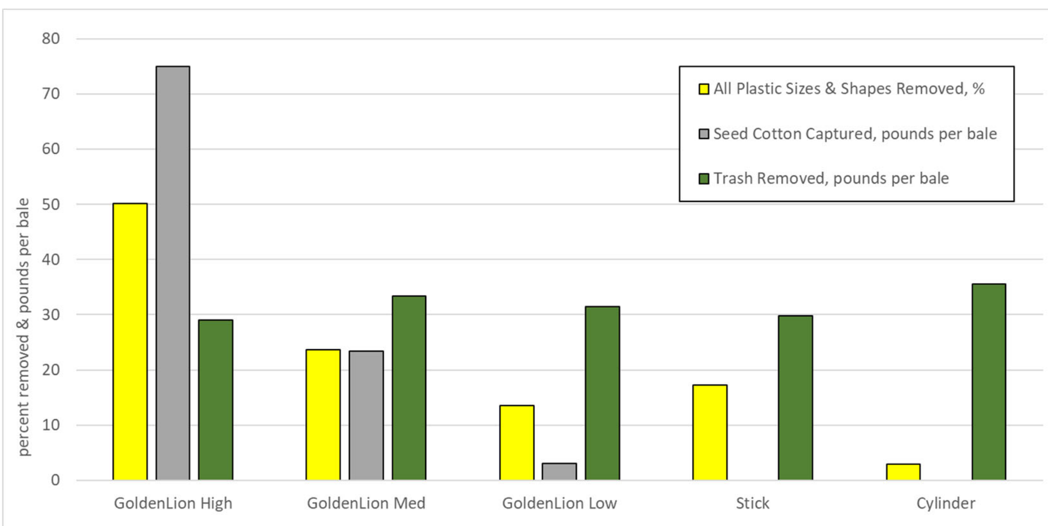

Figure 10. Results of all plastic sizes and types removed from the seed cotton, seed cotton captured with the plastic pieces, and trash removed by the GLCC (low, medium, and high air flow), stick machine, and cylinder cleaner.

Summary

The Handan Goldenlion Cotton Machinery Company Contamination Cleaner (GLCC) was tested to compare its performance to that of conventional seed cotton cleaners. Increasing the air flow to the GLCC improved plastic removal. Overall capture of plastic across all sizes and types increased from 13.5 to 50% when air flow was increased from 10,000 to 18,000 cfm. However, seed cotton captured with the plastic also increased from 3 to 75 pounds per bale. Shopping bag material and 1-ply non-tacky RMW (lighter, pliable) were removed better than multi-ply RMW (heavier, stiff). The GLCC with medium and high air flow was more effective at removing plastic contamination than the stick machine and the GLCC operated at all airflow rates was more effective than the cylinder cleaner. All the machines tested removed about the same amount of cotton trash (~30 pounds per bale).

Future Work

Video captured during testing revealed an issue that may be limiting the machine's performance. Images in Figure 11 show that often pieces of plastic adhered to the screen drum for separation (a) as designed. However, as the screen drum rotated (b) and the plastic piece reached the vertical position (c), the air circulating inside the machine stripped the plastic piece off the screen drum (d). It is unknown if those pieces of plastic were later collected on the screen drum again or if they recombined with the seed cotton flow. Further work is needed to investigate this issue and determine if it can be mitigated without increasing the amount of seed cotton captured with the plastic.

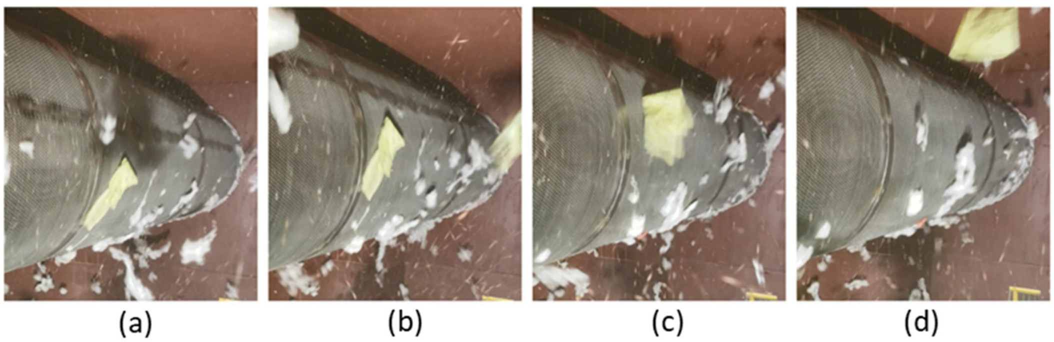

Figure 11. Video images of plastic pieces attached to and then stripped from the contamination cleaner screen drum by air currents.

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References

Rutherford, R.D. and G.J. Sweers. 2020. Field evaluation of the VIPR™ system. In Proc. 2020 Beltwide Cotton Conference, 575-579. 8-10 Jan., Austin, TX. Memphis, TN: National Cotton Council of America.