FIELD EVALUATION OF THE VIPR™ SYSTEM

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Abstract

The Lummus VIPR™ (Visual Imaging Plastic Removal) System is a commercial contamination detection/removal system for mounting on the feeder apron of an extractor feeder above a saw gin. Utilizing Bratney technology, along with developmental work by the USDA-ARS Lubbock Gin Lab supported through Cotton Incorporated, the first commercial prototypes of the unit were installed during the Fall 2019 gin season at a beta gin site in south Georgia. Results from the commercial validation/evaluation protocol testing on both yellow and pink round module wrap plastic are presented. The results from additional testing on alternative colors of round module plastic wrap (green and blue) are also included. All testing was performed under typical commercial production ginning conditions and capacities. This system is but one facet in the ongoing work by Lummus to address the critical issue of seed cotton and lint cotton contamination within the ginning industry.

Introduction

Contamination (primarily plastic, but also other non-cotton content) within seed cotton and lint cotton has been an ongoing issue within the cotton industry for years. When contamination makes its way through the processing stream (harvesting, ginning, spinning, etc.), it has a multi-million dollar negative impact throughout the marketing chain in the form of ruined or compromised fabrics and end products that must either be discarded or sold at lower-than-optimum prices. The problem has become such an issue that the USDA Agricultural Marketing Service has established two cotton classification levels (71 and 72) for contamination.

While plastic contamination is not a new issue, the broad adoption of on-board module cotton harvesters (which wrap the round modules in plastic) during the past two decades has increased the incidences of contaminated cotton reaching the gin. Once plastic makes its way into the gin machinery, it can be torn into small, difficult-to-remove pieces throughout the seed cotton and lint. Obviously, keeping the plastic from ever reaching the gin is the ideal solution, but it is not realistic, feasible, or likely to occur. Therefore, detection and removal systems throughout the ginning process must be developed to mitigate the contamination.

To this end, in 2017, the USDA ARS proposed research, funded by Cotton Incorporated, to develop a system for optical sorting of contamination. During 2017 and 2018, the USDA ARS partnered with Bratney Companies of Des Moines, IA, to design and refine a system, the first prototype of which was installed and tested on a Lummus Model 700 extractor feeder at Meadow Co-op Gin in Meadow, TX. Based on the initial success of the prototype, Lummus Ag Technology and Bratney Companies established a partnership to develop and commercialize the system, referred to as the VIPR™ and deliver it to a beta customer to demonstrate the effectiveness and potential in production conditions.

Background

Optical sorting can be broken down into two basic elements: detection and removal. For **detection**, there are multiple systems available, including black/white cameras, RGB cameras, NIR or InGas vision system, and hyperspectral. Each of these systems has to be considered for its ability to maximize contamination removal, while minimizing collateral removal of good product. Contamination **removal** can be accomplished a variety of ways, including mechanical diverters, air knife, and robotic systems.

The VIPR™ system uses RGB cameras and air knives in an assembly mounted over the feeder apron of the extractor feeder located directly above the gin stand. Figure 1 shows a typical installation of the camera cabinet assembly, while Figure 2 shows the cameras within the cabinet.

Figure 1. VIPR™ system on Model 700 Feeder at Southeastern Gin & Peanut, Inc.

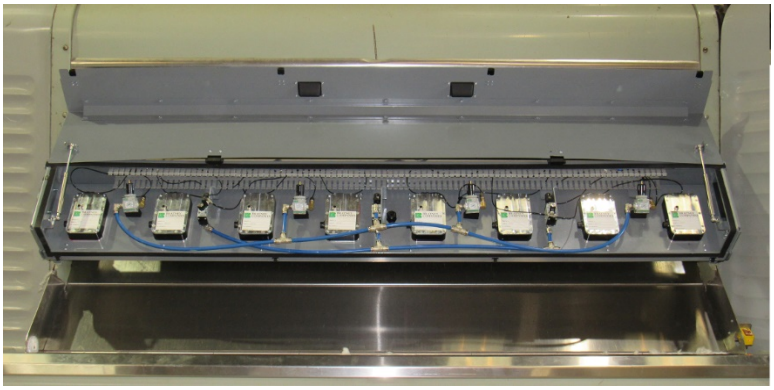

Figure 2. VIPR™ camera assemblies in cabinet (cover raised).

The VIPR™ system operates under the following concept/method. Cameras are mounted across the entire feeder apron (e.g., eight cameras on a 96" wide feeder), and each camera views approximately 14" of apron width (so there is a small overlap of coverage). Every pixel is analyzed to determine color, and based on color, the computer software sorts every pixel, categorizing it as either "good" or "bad." "Good" is considered as being anything that "looks" like cotton, stainless steel (the background of the feeder apron), and shadow area (area untouched by sufficient light to determine color). A "reject" is what is considered contamination or foreign material and comprises all the colors outside the profile. If there are enough "reject" pixels next to each other, the software algorithm classifies the pixel cluster as an object to remove. Based on the location on the apron, the computer decides which air knife (or knives) to fire in order to effectively remove the contamination. The air knives then release a blast of compressed air to remove the contamination. Air knives are set to turn on at the earliest possible time the contamination could be at the blast zone and turn off at the latest possible time the contamination could be in the blast zone. Collateral product removal is unavoidable but justified by the relative importance of removing contamination.

Materials and Methods

The beta site for this testing was Southeastern Gin & Peanut, Inc. in Surrency, GA. This gin plant features three (3) Lummus Model 700 extractor feeders over 170-Saw Imperial III saw gins. Two of the feeding/ginning lines were originally installed in 1995, while the third line was installed in 2014. The three VIPR™ units were installed in December of 2019 and tested during December, along with January and February of 2020.

Five (5) different module feeder plastic wraps were evaluated in this testing. TAMA, the manufacturer of the wrap, provided samples of conventional yellow and pink, along with two types of green (tacky and non-tacky) and blue (non-tacky). Figure 3 shows the colors used in the study.

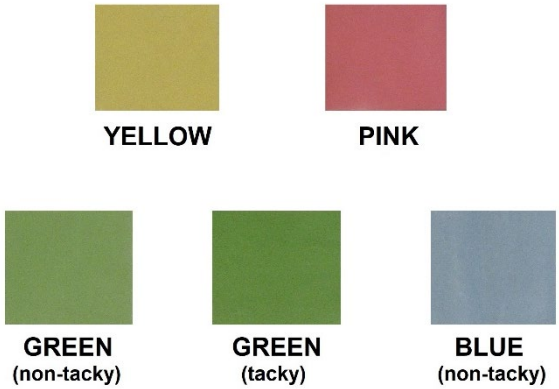

Figure 3. Module wrap colors evaluated at Southeastern Gin & Peanut, Inc.

Each of the lines was tested separately, so the facility could continue commercial operation on the other two lines. While any line was being tested, the gin front fire door was engaged in order to prevent any contamination pieces getting into the gin stand and subsequent machinery. Plastic pieces were injected into the free-falling seed cotton on the feeder apron just above the VIPR™ assembly. A collection sheet was taped across the upper gin front and held horizontally to capture the ejected pieces of plastic and seed cotton, while the other seed cotton and any undetected pieces of plastic would fall through the gin front fire door onto the gin floor. After each replication, the plastic pieces were collected from the collection sheet and counted, and the seed cotton pile on the floor was searched to retrieve any undetected pieces for counting. The size of plastic sample for this testing was 2" x 2". This is based on the fact that the USDA-ARS testing in 2018 used this size of contamination piece. Three replications of eight (8) pieces per replication for each color of wrap were performed. The pieces were injected across the entire width of the feeder in order to ensure that all the cameras and air knives were tested. The testing set-up arrangement is shown in Figure 4.

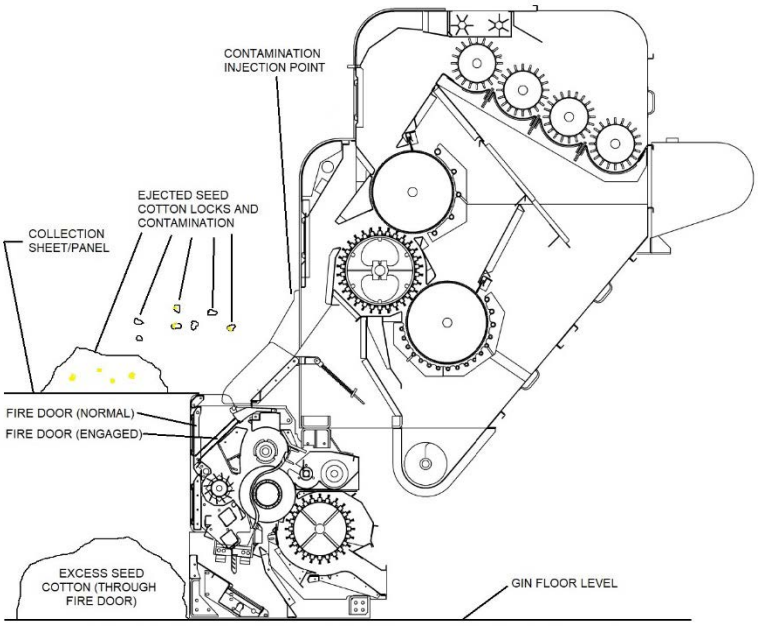

Figure 4. Testing set-up for VIPR™ system at Southeastern Gin & Peanut, Inc.

Results and Discussion

The results from the testing of all three lines and all colors of wrap are shown in Figure 5.

GIN LINE #1

YELLOW WRAP

Replication	Injected	Captured	
1	8	8	
2	8	8	
3	8	7	
OVERALL	24	23	95.83%

PINK WRAP

Replication	Injected	Captured	
1	8	8	
2	8	8	
3	8	8	
OVERALL	24	24	100.00%

GREEN (non-tacky) WRAP

Replication	Injected	Captured	
1	8	8	
2	8	7	
3	8	6	
OVERALL	24	21	87.50%

GREEN (tacky) WRAP

Replication	Injected	Captured	
1	8	7	
2	8	6	
3	8	7	
OVERALL	24	20	83.33%

BLUE (non-tacky) WRAP

Replication	Injected	Captured	
1	8	6	
2	8	7	
3	8	7	
OVERALL	24	20	83.33%

GIN LINE #2

YELLOW WRAP

Replication	Injected	Captured	
1	8	7	
2	8	6	
3	8	7	
OVERALL	24	20	83.33%

PINK WRAP

Replication	Injected	Captured	
1	8	7	
2	8	6	
3	8	8	
OVERALL	24	21	87.50%

GREEN (non-tacky) WRAP

Replication	Injected	Captured	
1	8	8	
2	8	7	
3	8	8	
OVERALL	24	23	95.83%

GREEN (tacky) WRAP

Replication	Injected	Captured	
1	8	8	
2	8	7	
3	8	6	
OVERALL	24	21	87.50%

BLUE (non-tacky) WRAP

Replication	Injected	Captured	
1	8	8	
2	8	7	
3	8	6	
OVERALL	24	21	87.50%

GIN LINE #3

YELLOW WRAP

Replication	Injected	Captured	
1	8	7	
2	8	8	
3	8	7	
OVERALL	24	22	91.67%

PINK WRAP

Replication	Injected	Captured	
1	8	6	
2	8	7	
3	8	7	
OVERALL	24	20	83.33%

GREEN (non-tacky) WRAP

Replication	Injected	Captured	
1	8	6	
2	8	8	
3	8	7	
OVERALL	24	21	87.50%

GREEN (tacky) WRAP

Replication	Injected	Captured	
1	8	7	
2	8	8	
3	8	7	
OVERALL	24	22	91.67%

BLUE (non-tacky) WRAP

Replication	Injected	Captured	
1	8	8	
2	8	8	
3	8	7	
OVERALL	24	23	95.83%

Figure 5. Composite test results from Southeastern Gin & Peanut, Inc.

The lowest collection efficiency for any line or color was 83.33%, while in one instance, a 100% collection efficiency was achieved on Gin Line #1 with pink wrap.

Combining the results from all colors tested in a specific gin line are presented in Figure 6.

Combined Colors by Gin Line

Line	Injected	Captured	Efficiency
Line 1	120	108	90.00%
Line 2	120	106	88.33%
Line 3	120	108	90.00%
TOTAL	360	322	89.44%

Figure 6. Collection efficiency by gin line over all colors (combined).

The results for each color of wrap from the combined ginning lines are shown in Figure 7.

Combined Lines by Wrap Color

Wrap Color	Injected	Captured	Efficiency
Yellow	72	65	90.28%
Pink	72	65	90.28%
Green (non-tacky)	72	65	90.28%
Green (tacky)	72	63	87.50%
Blue (non-tacky)	72	64	88.89%
TOTAL	360	322	89.44%

Figure 7. Collection efficiency by wrap color across all ginning lines.

Collection efficiency for yellow, pink, and green (non-tacky) were over 90%, and combined (all colors), the overall collection efficiency of the VIPR™ was 89.44%.

In a side note to the actual testing of the VIPR™ system, at the conclusion of one of the replications, a silver and multi-colored Mylar® party balloon was detected and ejected from Gin #1, and it is shown in Figure 8.

Figure 8. Mylar® balloon detected and ejected by the VIPR™ System.

Summary

In its initial commercial prototype season under limited operation, the VIPR™ system exceeded expectations, in which it was hoped that 75% detection/ejection results could be achieved. While no system will be 100% effective, the VIPR™ can offer a significant opportunity to detect and remove a substantial amount of contamination before it reaches the gin stands and subsequent machinery. Certainly, more research, testing, development, and refinement of the system will be ongoing, including installations in gin plants across the U.S. cotton belt and around the world.

Acknowledgements

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