PLASTIC IMPURITIES FOUND IN COTTON

Brandee Haney
R. K. Byler
USDA/ARS Cotton Ginning Research Unit
Stoneville, MS

Abstract

The United States cotton industry has been producing top-quality cotton for decades. According to surveys from the National Cotton Council and the International Textile Manufacturers Foundation, US produced cotton is among the least contaminated in the world. Even though the US has the least contaminated cotton compared to other countries, studies show that over the years, the levels of contamination are increasing. This dilemma has the potential to damage the reputation of cotton grown in the US. The challenge of keeping cotton free of contamination by foreign materials must be addressed. Foreign material is an impurity, whether organic or inorganic, that gets inadvertently mixed with cotton in the harvest and post-harvest processes. Foreign materials can range from plastic grocery bags to oil or grease. These contaminants have the potential to make it through the various stages of textile production and end up ruining many yards of cotton yarn. Over the years, the cotton industry has invested in expensive equipment to remove contaminates from cotton.

Introduction

Non-cotton impurities such as plastic, nylon, oil and grease can impair producers' relationships with textile manufacturers, undermine promotional activities and threaten U.S. cotton's excellent reputation. Other contamination arises from impurities being incorporated into the bale because of human interaction during harvesting, ginning and baling. These contaminates have the potential to make it through the various stages of textile production and end up ruining many yards of cotton yarn. Lower quantities of non-lint in harvested cotton decreases the need for lint cleaning treatment thus affecting profit margins for cotton producers and enhancing the overall cotton quality for yarn and fabric formation. The creation of quality measurements must enhance the value of cotton using a method that is accurate, precise, and fast. Contaminants such as shown in Figure 1 can end up in finished yarn and fabric products, resulting in defective fabrics and clothing seconds sold at a fraction of their original value. Tainted products are costly to textile manufacturers and undermine consumer appeal. Spinners calculate which raw materials they can blend to produce yarns and fabrics that satisfy their customers.

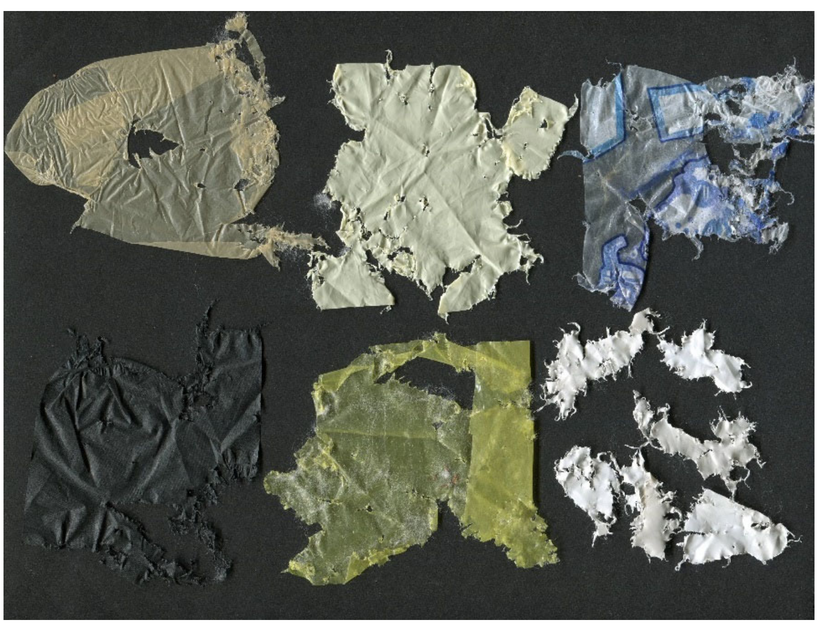

Figure 1. Plastic contamination retrieved from gin waste & lint.

Discussion

To convert a fiber into yarn, cotton passes through various processes in a spinning mill. A large number of machines mechanically reduce the size of most foreign matter clusters into individual foreign fibers or pieces. These fibers can remain undetected under normal mill processing conditions and only become noticeable when the production process is interrupted, by a spinning end break or when the yarn is used to make up fabric and the fabric is subjected to normal quality control inspection. Contamination represents a significant cost to spinning mills. Thus, it is very important to detect and eliminate contamination as early in the process as possible.

Some plastic materials, which can be found in gins and can sometimes gets mixed with the lint are shown in Table 1. Of these plastics, the PE film contamination has received the most attention recently (Valco, 2016).

Table 1. Certain plastic materials, which may contaminate cotton lint at the gin.

Material	Abbreviation	Common use
Polyethylene terephthalate	PET	Bale ties, module covers, food containers
Polyethylene	LDPE, HDPE, PE	Shopping bags, module covers, bale bags, clothing
Polypropylene	PP	Bale bags, twine, rope, bottles, clothing
Polyvinyl chloride	PVC	Pipes, module covers, fittings, wire insulation, packaging

Issues for producers and ginners

While there is not one obvious source or type of contamination, plastics are the most frequent culprit (Valco, 2014). Ginners need to be aware of plastic trash that collects in the cotton field, especially shopping bags, black plastic film used for mulch, plastic twine typically used in baling, and yellow plastic film used as round module wrap (Valco, 2014). There are steps that can be taken at different stages to help alleviate contaminates entering the cotton stream. According to Chammoun (2015), "For cotton growers, the easiest thing to do is to be meticulous in inspecting cotton harvesters for any unnecessary grease, fluid leaks, or foreign materials that may have accrued. Also, be aware of any debris that could be potentially taken up during the harvest process, such as plastic grocery bags shown in Figure 2 and plastic mulch are very lightweight and can easily be picked up by the harvester." Once these items enter the harvester they may be torn or shredded and can possibly effect an entire module of cotton.

Figure 2. Plastic removed in seed cotton cleaning waste.

For cotton gins, contaminates may be found at the gin or transferred from the field by module trucks. Chammoun (2015) stated, “Ginners need to be aware of any foreign material found on equipment or on the gin floors. Take extra time prior to ginning the first module to inspect all equipment to ensure that there are no contaminates located in or around the ginning equipment. Inspect module trucks for foreign materials such as plastics or rope that may have been picked up in the field.” Also, be sure to instruct all gin employees on the proper procedures to safely unwrap round modules and not use torn module covers for traditional modules that may introduce contaminates into the cotton.

Storing cotton in modules in the field allows pickers to operate continuously during optimum harvesting conditions. Over time, module covers may deteriorate and tear, leaving pieces of plastic on seed cotton as contamination. More often, the practice of using plastic twine to tie down module covers leads to contamination problems. Even a short piece of plastic twine or rope can contaminate several bales of cotton if the material enters the gin. The foreign material will be shredded and dispersed into the lint.

Plastic irrigation ditch liners left in the field may be picked up by harvesting equipment and become mixed in with the seed cotton. If not removed, this plastic can travel through the gin with the seed cotton, possibly get shredded and remain with the ginned lint. These small pieces of plastic cause major problems at textile mills by increasing spinning costs and by their very presence in fabric. As a result, large quantities of fabric must be sold as defective materials or seconds.

Trash as shown in Figure 3 may have blown into a field from the roadside is also a contaminant. Debris such as small plastic bags can be picked up by harvesters and ginned with the seed cotton. Contaminants can end up in finished yarn and fabric products, resulting in defective fabrics and clothing seconds sold at a fraction of their original value. Tainted products are costly to textile manufacturers and undermine consumer appeal. Spinners carefully calculate which raw materials they can blend to produce yarns and fabrics that satisfy their customer requirements. There is no room for contaminated cotton lint in that mix. Eliminating impurities from cotton as effectively and comprehensively as possible is an essential precondition for manufacturing textile products for critical markets.

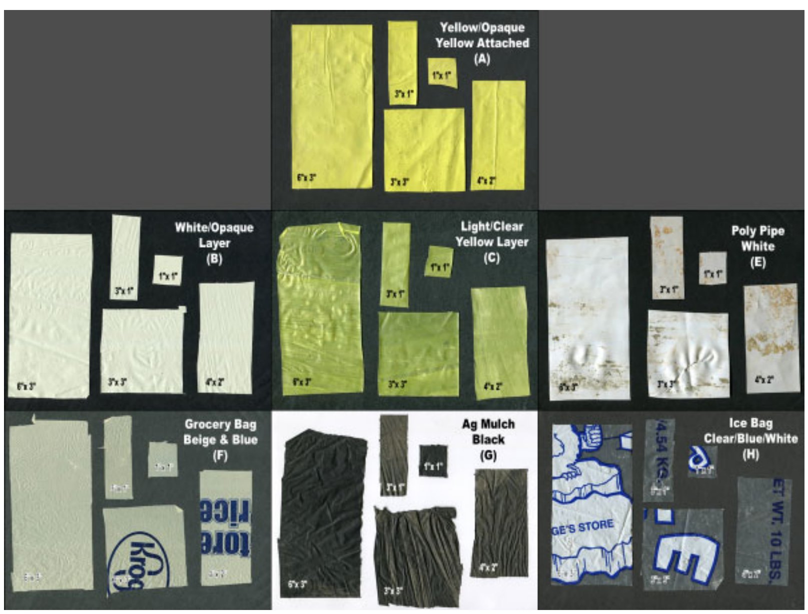

Figure 3. Different types of plastic contaminants.

The plastic contaminants entering the gin typically are broken up into many smaller pieces by the mechanical processes of the gin so that they become more difficult to detect (Valco, 2014). Plastic particles often then cause serious problems and faults in the course of processing in the spinning mill. As well as increasing spinning costs, this can also result in impaired quality, causing price reductions for the fabric produced in downstream processing.

Reduction of contamination

Simple measures can be taken to reduce the levels of contamination. One of the simplest is walking the cotton fields and removing debris prior to harvest. This is of particular importance where fields are close to highways where trash may be thrown out of car windows. It is also of particular importance to check fields for debris when storms with high winds may have blown debris into fields. Several ways to avoid cotton contaminated with plastic is to replace old plastic tie downs and ropes with newer cotton types or at least make sure they are in good condition, and make an extra effort to remove all covers and tie downs before cotton reaches the suction or module feeder. Keeping all hats, gloves, and cleaning rags away from gins and seed cotton can help avoid contamination due to apparel fibers.

Immediately after spinning the contamination may not be visible by the naked eyes, but can be detected by the optical clearing sensors, which will remove the contamination along with the yarn as waste material. The loss of yarn and production cost matters a lot. With that being said, it is beneficial to remove the contamination before going into further processes, which means in the blow room department itself when the cotton is in open condition.

The increasing demand for contamination-free yarns has led to the invention of equipment, like Jossi Vision-Shield©, Barco, Loptex, capable of detecting and removing contaminants at the blow room stage. All these systems call for huge investments by the textile industry, which is already working with very low margin. According to the National Cotton Council, "The textile industry transformed its capabilities by investing almost $2.5 billion annually since the early 1980s. Mills now offer a wider variety of high quality, competitively priced products in a timelier manner." The American Textile Manufacturers' Association (2016) stated, "The number of actual spinning positions in mills fell from 17 million to less than 7 million in a 10-year span. Production of cotton per spinning position, however, increased to nearly 600 pounds, tripling the rate a decade ago."

Barco is a technology company that contributes to the textile industry with their optical sensor technology, providing several products that can be added to existing cotton yarn spinning plants for the detection of foreign materials. These include the CottonSorter© and SliverWatch©. For the blow room, Barco offers CottonSorter©, which is designed to be added after the bale opener. According to automation in Textile Industry, "This machine detects foreign materials with "ultra-fast" CCD cameras and removes them from the cotton tufts with high-speed pneumonic guns."

Automation in Textile Industry states that, "The CottonSorter© sends the cotton tufts through a transparent tunnel where the fibers are illuminated and four CCD line scan cameras observe from both the top-down and bottom-up. These images are processed and foreign fibers are identified based on color and size difference in comparison to cotton fibers. The machine judges the downstream speed of the fiber flow and ejects identified contaminants with the high-speed air guns at the optimal moment. The touch-screen user interface enables the operator to set tolerances. This allows the machine to be more strict or lenient depending on the end-use of the cotton or other conditions. The machine also reports the size and color of foreign fibers in case the plant manager has a need for this data."

The Indian Textile Journal (2008) states that, "Barco's SliverWatch© is designed to detect foreign materials among the cotton fibers. It will also immobilize the draw frame or lapper. This allows manual elimination by the operator. SliverWatch© passes the sliver through a sealed transparent guide, which is illuminated with either transmitters or light emitting diodes. Receivers are positioned to absorb the amount of light in the sealed sensor. Foreign material will absorb a different amount of light than cotton fiber, resulting in a different reading in the receiver. This is the operating principle by which this system detects contaminant fibers. SliverWatch© will also detect sliver breakage or the lack of a special colored fiber if it is expected. This is the case with fancy yarn or cotton/black polyester heather yarn production."

Loepfe Brothers Ltd is a smaller company that concentrates on textile online quality control. They provide a variety of products for spinning and weaving that can be applied to pre-existing textile machinery. According to the Loepfe Brothers Ltd (2008), "The YarnMaster Zenit FP© (Loepfe Brothers Ltd. 2008) model is the one capable of advanced detection because of the P-Sensor. The P-Sensor uses a triboelectric measuring principle, in which the fibers exchange electrons with the sensor. Foreign fibers are detected because they result in a different voltage than does cotton when passed over the electrode. This feature makes the P-Sensor capable of finding fibers that are too transparent, fine, or cotton-colored to be detected optically. With P-Sensor combined with the optical sensors, the YarnMaster Zenit FP© system provides comprehensive yarn clearing."

Jossi Vision Shield T© incorporates three different contamination detection methods. Uster states, "They ensure extraordinary performance and clean cotton. Top technology means improved final products and always meeting customer quality requirements concerning contamination level. The detection capabilities of the Uster Jossi Vision Shield 2© come from new sensors and the Powerful Imaging Recognition Technology (PIRT). This is a sophisticated image analysis technique perfected by Uster. The smallest particle of contaminant will be picked out, helped by sophisticated image recognition. The greater sensitivity of the system has already proven its effectiveness in trials, recording significantly improved detection of polypropylene, a common contaminant in raw cotton."

Dodbiba and Fujita (2004) discuss several techniques for separating dissimilar plastics or separating plastic material from other dissimilar materials. One approach, which has been useful, is to float the materials in water. Many of the plastics are less dense than water so they float while other materials sink. This approach seems unlikely to be useful in the cotton gin.

Another flotation type approach discussed by Dodbiba and Fujita (2004) uses air to move less dense materials up in an air column while more dense materials sink. This separation depends on the aerodynamic properties of the particles, which includes shape and size in addition to the material density. A similar design to the air column separator uses a vibrating porous deck through which air is blown designed to move some materials to one side and other materials to the opposite side.

The triboelectric effect is a type of electrical charging occurring when certain dissimilar materials are mechanically rubbed together. Common example is when a comb is pulled through hair or fir is rubbed on glass. These forces can be destructive, such as static damage to electronics, but can also be used to separate dissimilar materials, which are mixed together. The propensity to create charges between two materials has been made into a series and certain materials from this series are listed in Table 2 (AlphaLab Inc.).

Table 2. Selected triboelectric factors.

Material	Affinity nC/J
Paper	+10
Cotton	+5
Acrylic (polymethyl methacrylate)	-10
PET – such as plastic bale ties	-40
Vinyl	-75
Olefins (LDPE, HDPE, PP) – such as shopping bags, module covers, bale bags	-90
PVC	-100
Polytetrafluoroethylene (PTFE) (Teflon)	-190

The table may be used to choose materials which will not result in large charges when rubbed together to avoid static electrical problems or may be used to estimate charges on the materials. In this case, it can be observed that cotton is relatively low at +5 nC/J and the plastic contaminants are rather different mostly at -90 nC/J. Dodbiba and Fujita (2004) discuss several methods that have been used to rub the materials together, including feeding the mixture with a vibrating feeder, through a rotating drum, or using a cyclone. The actual forces generated are usually rather modest. The mixture is fed between two oppositely charged electrodes after the mixture is charged and the materials will fall toward the electrode of opposite charge, or will be unaffected by the electrodes if not charged or only slightly charged thus achieving separation.

Electrostatic separation by corona charging is similar to the triboelectric separation; however, the electric charge is imposed by an electronic generator. A relatively high voltage difference causes ionization of the air especially when the voltage is applied to a specially designed electrode with one or several sharp angles. Of course, arcing will occur if the voltage is high enough which would be a problem when materials, which may burn, are present. With proper orientation, these ions will pass the charge to plastic materials, which will then adhere to a neutral metal surface while other materials, such as cotton, are substantially unaffected. The plastic materials, stuck to the metal surface, could then be removed at a different location than where the cotton fell off.

Conclusions

In conclusion, measurement and control of foreign matter in cotton spinning will always be important because the presence of contaminants has a negative impact on both process and product quality. Foreign fibers are easily camouflaged among cotton fibers. Technology exists and is available from several textile manufacturers that will detect foreign matter by means of a variety of sensors. The cost of this technology may preclude many gins and some yarn spinners from benefiting from such advancements. In addition, depending on the end use of the yarn in question, it may be less important for manufacturers to avoid foreign matter at all costs. The different equipment discussed has helped, but there is always room for advancement. Even though Dodbiba and Fujita's techniques would not be useful in the gin, they can also be used elsewhere in the textile industry. In the end, it all depends on individual situation. While strides have been made, there is still a room for improvement in the measuring and controlling of foreign matter in the cotton yarn spinning industry.

Acknowledgements

The authors wish to thank Cotton Incorporated for their financial support of this project under Cooperative Agreement No. 14-489, Evaluation of Opportunities to Remove Plastic during the Ginning Process.

Disclaimer

Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the U. S. Department of Agriculture and does not imply approval of the product to the exclusion of others that may be available.

References

AlphaLab Inc. TriboElectric Table. [Online]. Available at https://www.trifield.com/content/tribo-electric-series/ (verified 13 Dec. 2016).

American Textile Manufacturers' Association. 2016. Textiles Thrive On Cotton. [Online]. Available at http://www.cotton.org/econ/textiles/cotton-and-textiles.cfm (verified 2 Dec. 2016).

Automation in Textile Industry [Online]. Available at http://textilepapers.tripod.com/automation.htm (verified 14 Dec. 2016).

Barco SliverWatch Supplementary Manual [Online]. Available at https://all-guides.com/manual/56057/barco-sliverwatch-supplementary-manual-4.html?page=2 (verified 29 Nov 2016).

Chammoun, Chris. 2014. Help keep Contaminants out of US Cotton. [Online]. Available at http://www.southeastfarmpress.com/cotton/help-keep-contaminants-out-us-cotton (verified 30 Nov 2016).

Dodbiba, D. and T. Fujita. 2004. Progress in Separating Plastic materials for recycling. *Physical Separation in Science and Engineering*. 13:3-4. Pp 165-182.

Loepfe Brothers Ltd. 2008. Unlimited scope in YarnMaster Zenit FP. [Online]. Available at http://www.indiantextilejournal.com/articles/FAdetails.asp?id=1053 (verified 7 Dec 2016).

National Cotton Council, PREVENT LINT CONTAMINATION. . . clean cotton means satisfied customers! PROTECT YOUR COTTON FIBER. . . and you will preserve your markets! [Online] Available at http://cotton.tamu.edu/Harvest/prevent-lint.pdf (verified 28 Nov 2016).

SliverWatch to eliminate contamination, 2008 [Online]. Available at http://www.indiantextilejournal.com/products/PRdetails.asp?id=554 (verified 14 Dec 2016).

Uster, Uster presents new Uster Jossi Vision Shield 2 for ultimate fibre cleaning, 2015 [Online]. Available at http://www.innovationintextiles.com/uster-presents-new-uster-jossi-vision-shield-2-for-ultimate-fibre-cleaning/ (verified 15 Dec 2016).

Valco. T. 2014. Industry must stop contamination. Cotton Farming, Sept. 2014. pp. 14.

Valco, T. 2016. Scout for plastic to prevent cotton contamination. [Online]. Available at http://www.deltafarmpress.com/cotton/scout-plastic-prevent-cotton-contamination (verified 13 Dec. 2016).