35th INTERNATIONAL COTTON CONFERENCE BREMEN 2021

PAPER

Session:

Cotton Quality & Testing 1 (T4)

Presentation Title:

Contaminants in Cotton - Still a Major Issue for High Quality Products

Speaker:

Marinus van der Sluijs, Textile Technical Services, Geelong, VIC, Australia

Presentations are available on the conference archive:

https://baumwollboerse.de/en/cotton-conference/lectures/

Conference Organization
Faserinstitut Bremen e.V., Bremen, Germany. E-Mail: conference@faserinstitut.de
Bremer Baumwollboerse, Bremen, Germany. E-Mail: info@baumwollboerse.de

CONTAMINANTS IN COTTON - STILL A MAJOR ISSUE FOR HIGH QUALITY PRODUCTS

M.H.J van der Sluijs

Principal Consultant, Textile Technical Services, Geelong, Victoria, Australia.

ABSTRACT

Contamination in cotton, even if it is a single foreign fibre, can lead to the downgrading of yarn, fabric, or garments, or even to the total rejection of an entire batch and can cause irreparable harm to the relationship between growers, ginners, merchants and textile and clothing mills. Contamination thus continues to be a very important cotton fibre quality parameter in the production pipeline, with countries and cotton that are perceived to be contaminated heavily discounted. At the same time spinners are implementing various methods to detect and eliminate contamination. This paper provides some insight into the incidence, detection, measurement, consequences, and reduction of contaminants in cotton.

INTRODUCTION

Due to the increasing demands of modern spinning, raw material cost and the increasingly competitive global textile market, cotton fibre quality, in terms of length and uniformity, strength, micronaire, trash content and extraneous matter, is of the utmost importance to the spinner. In addition, the presence of contaminants, particularly foreign fibre, can greatly affect its perceived quality and value. Various sources of contaminants, such as paper, plastic, feathers etc. as described in Table 1, can be incorporated into the bale as a result of human interaction during harvesting and ginning, and even in the spinning mill itself (van der Sluijs 2007a, van der Sluijs 2007b). This contamination, even if it is a single foreign fibre, can lead to the downgrading of yarn, fabric, or garments, and/or even to the total rejection of an entire batch, resulting in large financial claims and losses, which can cause irreparable harm to the relationship between growers, ginners, merchants and textile and clothing manufacturers.

Depending upon its nature, spinning and fabric processing method as well as the end-use, contamination can adversely affect textile processing efficiencies, due to end breakages during yarn and fabric formation, cause damage to processing equipment (such as beaters and wire), and even cause fire in the mill. More importantly, contamination can adversely affect the appearance of the yarn, fabric and final product (Hunter 1989, Schlichter and Loesbrock 1997, Narkhedkar and Lavate 2011, Biermann 2018), especially in fine count yarns (Haldermann and Keller 1992), resulting in such products having to be sold as seconds.

It has been stated that even though the levels of foreign fibre contamination has been drastically reduced, due to various corrective actions, it still represented the number one problem for manufacturers of high quality cotton products (Walraf 2000, Hamai 2003). It is also worth mentioning, that contamination can occur, and present a serious problem, in most other natural fibres, such as wool and mohair, but seldom in man-made fibres.

In the light of the above, it is not surprising that there are serious penalties for contaminated cotton (Anon 2007). In 2002, the International Textile Manufacturers Federation (ITMF) reported that claims, due to contamination in cotton, amounted to between 1.4 and 3.2% of total cotton and blended yarn sales. Recognizing the slim margins on which spinning mills operate, these figures illustrate the serious affect which contamination has on spinning mill profit margins (Strolz 2002). In fact, it was reported in 2015 that contamination related losses amounted to US$200 million per year worldwide (Potter 2015). A study conducted by Ahmedabad Textile Industry's Research Association showed that 70% of knitted fabric complaints produced from 20 tex combed yarns were due to contamination, with 80% of the contamination due to human hair and jute and 14% due to coloured cotton fibre (Garde, Shah et al. 1996). It has also been stated that the presence of coloured fibres in fabrics can result in bleeding during bleaching, resulting in the finished fabric being cut, replaced or redyed with other colours (Zhou 2017). It has also been reported that contamination related complaints and claims amount to approximately 15% of all yarn complaints (Sharma 2013). It has been stated that the more steps there are in the spinning process, the more difficult it is for any foreign fibre to be detected as the distance between any such foreign fibres increases with the number of stages, due to increased drafting ratios. For example, the distance between foreign fibres is longer in combed ring-spun yarns than in rotor-spun yarns (Thilagavathi and Karthik 2013).

The issue of contamination is nothing new, and spinning mills have for a long time lodged complaints and produced evidence of contamination found in cotton bales they have purchased, with the first recorded official complaint raised as far back as 1909 (Anon 1909). Indeed, there is a feeling amongst mills, which is borne out by the ITMF Contamination Surveys, that contamination is increasing and that the cotton trade (growers through to merchants) has done little to eliminate or reduce the incidence of contamination (Schoeller and Blum 2000, Anon 2017). There are, however, no established international or universal standards relating to contamination size and frequency, most end-users demanding zero contamination. As a consequence, the more quality conscious spinners have defined their own allowable levels of contamination, and developed a range of screening protocols in order to assess the contamination risk associated with the various sources or origins of cotton (Patodia 2003, Strolz 2004, Anon 2006).

The weight of contaminants in cotton bales can range from 1 to 100 grams/ton with contamination rates of 1 to 4 grams /ton considered low, 5 to15 grams/ton moderate and above 20 gram/ton as high (Anon 2007, Estur 2008). It has been suggested that, if the level of contamination is less than 1 gram/ton, and all other remediation controls are in place, the contamination in fabric and garment would be minimal. Although, at 0.001% by weight, such level of contamination appears to be extremely small, it must be remembered that contamination is quantified by the number and frequency of incidents, rather than by their weight, and 0.001% by weight can equate up to 15000 fibres (Vijayshankar 2006a, Anon 2008, Sharma 2014). It has been stated that losses can be at least 1000 times more expensive than if the contaminants were found in the bale prior to processing (Herber, Mayfield et al. 1990).

As blending of cotton lint from various parts of the world is a standard practice for spinning mills, it is often difficult for a mill to pinpoint the origin of the contaminants once an incident or complaint has been received. Nevertheless, through the practical experience of mill staff and industry hearsay, cotton purchases from origins that are known, or perceived, to be contaminated, are either avoided or the use of those growths minimized.

This is not always easy since the majority of cotton is produced in Asia from which the most heavily contaminated cottons originate (Schlichter and Loesbrock 1997). Once an origin has achieved a reputation for contamination, the likelihood of it achieving base world market prices is slim, and cottons from that origin are usually heavily discounted, ranging from 5 to 30%, even if the fibre quality is acceptable (Patodia 2003, Anon 2008, Estur 2008, Knappe 2014). Also, some mills will not, unless heavily discounted, purchase hand-picked cotton, due to the typically high incidence of contamination (Anon 2007, Estur 2008, van der Sluijs 2009, Zhou 2017), this despite the fact that hand-picked cotton generally has fewer neps and short fibres and better length uniformity. This is in contrast to cottons from Australia and the US, which continue to achieve premiums for their cotton, due to their reputation of having low contamination levels (Gordon, van der Sluijs et al. 2004, van der Sluijs, Shankar et al. 2004a, van der Sluijs, Shankar et al. 2004b, van der Sluijs 2007a, van der Sluijs 2007b, van der Sluijs 2009, van der Sluijs and Johnson 2011).

ITMF CONTAMINATION SURVEYS

Because of the global cotton industry's growing concern about contamination, and in order to quantify the type and level of contamination found in cotton, the ITMF has been conducting biennial contamination surveys of cotton mills.

The ITMF defines 16 categories of contamination, which are listed in Table 1. In the survey, mills are asked to indicate the sources of contamination according to the 16 categories, and to indicate, in each category, whether the contamination level was non-existent/insignificant, moderate, or serious. The survey thus, in essence, records the perception of spinners and can therefore be regarded as an 'opinion poll', and not based on scientific or quantifiable evidence, but can, nevertheless, still be considered a valuable source of information and data for the industry (Strolz 1998, Pavaskar and Pavaskar 2016). It must be borne in mind that there are other contaminants, such as rocks, stones, human hair etc., present in cotton that are not covered by the ITMF categories.

Table 1 ITMF Contamination Sources (Anon 2017)

No.	**General contaminant**	**Specific contaminant**
1	**Fabrics made of**	Woven plastic
2		Plastic film
3		Jute/hessian
4		Cotton
5	**Strings made of**	Woven plastic
6		Plastic film
7		Jute/hessian
8		Cotton

9	**Organic matter**	Leaves, feathers, paper, leather, etc.
10	**Inorganic matter**	Sand, dust
11		Rust
12		Wire, metal
13	**Oily substances/chemicals**	Grease/oil
14		Rubber
15		Stamp color
16		Tar

Across all growths, the incidence of contamination, labelled 'moderate' or 'serious' (see Table 2), increased steadily from 14% of all bales surveyed in 1989 to 26% in 2003, followed by a decrease to 22%, stabilizing at this level between 2005 to 2009. This was followed by a slight increase to 23% in 2011, a further increase to 26% in 2013 and then a reduction to 23% again in 2016 - see Figure 1. What is notable is the dramatic increase in contamination worldwide from 1993, which is attributed to spinners becoming more aware of contamination, as the number of complaints received from fabric and garment manufacturers increased, as well as consumers becoming more quality conscious (Anon 2017). Another reason could also be that, increasing automation and the subsequent reduction in labour lead to reduced human vigilance and opportunities to detect and eliminate contaminants, specifically in the ginning and spinning mills (Hunter 1989, Herber, Mayfield et al. 1990, Van Nimmen and van Langenhove 1998, Hamilton, Thoney et al. 2012). A further reason could also be that the installation of automatic detection systems in the spinning mills provided more accurate information on the type and frequency of contamination.

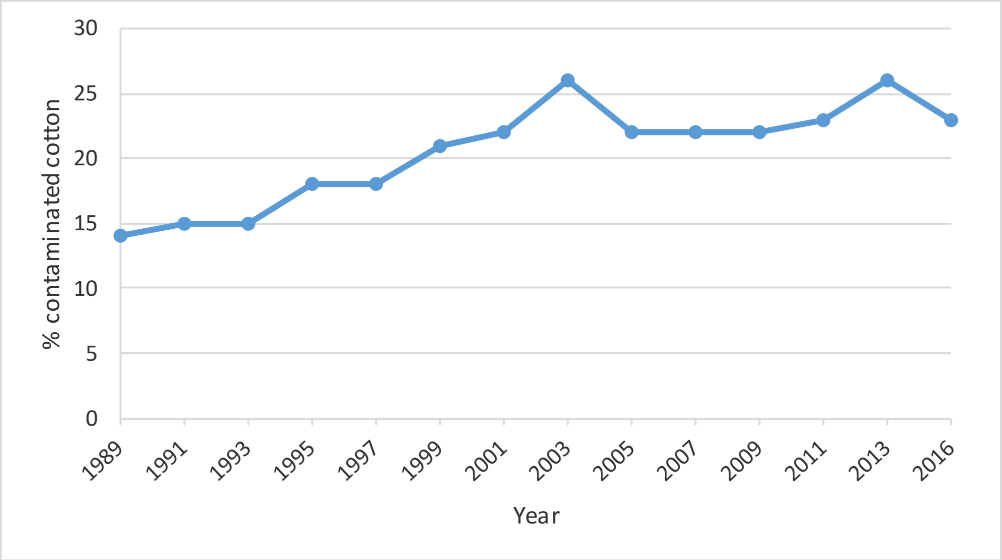

Figure 1 ITMF Contamination survey results from 1989 to 2016 (Anon 2017)

Table 2 gives the worldwide averages, per contamination category, recorded during the surveys (Anon 2017). As can be seen the major source of contamination, in all cotton bales, continues to be organic matter, such as leaves, feathers, paper and leather, which has steadily increased from 30% in total in 1989 to a high of 55% in 2013, then decreasing to 47% in 2016. The next most prevalent contaminants are pieces of fabric and string made from woven plastic and plastic film, followed by jute/hessian, which originate from bale covers and picking bags and cotton both natural and coloured, mainly from bale covers but also from apparel, cleaning rags and module ropes. This is followed by inorganic matter, such as sand/dust, rust, and metal wires, which are followed by oily chemical substances, such as grease and oil, mainly due to excess lubrication, worn seals and hydraulic oil leaks during harvesting and ginning, stamp colour (mainly due to using permanent markers to identify modules or bales) rubber and tar. The incidence of oily chemical substances and inorganic matter, such as rust and metal, has remained fairly constant since 1989.

Fabric and string contaminants mainly originate from module covers for both conventional and round modules, plastic shopping and fertiliser bags, agricultural mulch film, plastic twine, irrigation tubing and to a large extent bale covers, which are damaged during warehousing and shipping (Blomquist 1997, Simpson 1998, Van Nimmen and van Langenhove 1998, Jordan 2004). The incidence of plastic contaminants is becoming a major problem in countries such as Australia, Brazil, Israel, the US, and other countries which have adopted the new John Deere spindle and stripper harvesters which produce round modules covered with plastic wrap (van der Sluijs and Krajewski 2015, Haney and Byler 2017, Whitelock, Byler et al. 2017).

Table 2 Percent of contaminants found in cotton worldwide (Anon 2017)

Contaminant	**1989**	**1991**	**1993**	**1995**	**1997**	**1999**	**2001**	**2003**	**2005**	**2007**	**2009**	**2011**	**2013**	**2016**
Fabrics														
Woven plastic	13	15	16	16	19	20	23	29	25	23	25	28	29	31
Plastic film	11	12	11	14	14	16	21	24	25	30	26	24	31	38
Jute/hessian	15	18	19	22	20	25	24	30	21	27	25	23	25	27
Cotton	18	19	19	19	21	24	28	31	32	30	27	30	36	27
Strings														
Woven plastic	15	14	17	20	31	25	24	32	29	25	29	29	36	31
Plastic film	14	13	12	18	18	22	22	28	26	29	23	28	31	30
Jute/hessian	22	21	24	30	25	30	30	38	25	29	32	27	34	29
Cotton	17	16	16	19	18	25	22	30	24	26	26	26	38	24
Organic matter														
Leaves, feathers, paper, and leather	30	28	29	34	34	39	39	50	40	40	42	51	55	47
Inorganic matter														
Sand/dust	16	20	19	25	23	30	28	37	29	25	26	31	33	31
Rust	10	13	12	13	13	18	15	20	15	13	15	16	15	14
Metal/wire	15	12	13	14	15	16	18	21	12	17	15	15	18	13
Oily substances/chemicals														
Grease/oil	14	14	15	20	18	23	22	23	16	17	16	13	14	11
Rubber	4	5	4	5	6	6	7	9	7	9	8	6	10	6
Stamp colour	12	15	12	14	14	14	16	17	15	11	11	8	9	10
Tar	3	3	2	4	4	4	6	6	5	5	4	5	7	5
Designation														
Non-Existent/insignificant	86	85	85	82	82	79	78	73	78	78	78	77	73	77
Moderate	9	11	11	13	13	15	16	18	15	15	16	16	18	18
Serious	5	4	4	5	5	6	6	8	7	7	6	7	8	5

As already mentioned, the degree of contamination varies widely from country to country and region to region and is related to different farming, harvesting and ginning practices. No particular cotton is contaminant free, with the least contaminated cotton still having contamination levels of 4 to 5%. According to the ITMF surveys, the most contaminated cottons continue to originate from India, Turkey, Africa (various countries) and Central Asia, with the least contaminated cotton continuing to originate from the US, Israel, Australia and from certain countries of West Africa.

METHODS TO DETECT AND ELIMINATE CONTAMINANTS

Contamination represents a significant cost to spinning mills and thus it is important to detect and eliminate it as early in the process as possible. This has led to the development and implementation of a range of methods and behaviours to detect and remove contamination from the processing pipeline (van der Sluijs, Shankar et al. 2004b).

Cotton passes through many processing stages in a spinning mill, each of which can be affected differently by contaminants in the cotton, depending upon their size and type, nevertheless, the stages can also present opportunities to detect and eliminate the contaminants. Contamination in cotton occurs in many types, shapes, and sizes and, whilst larger pieces of contaminants are more likely to be removed during processing, each mechanical process has the potential to reduce the size of the contaminants into a large number of fragments, particles or fibres, the latter being particularly problematic. Foreign fibres, when present, tend not to be distributed uniformly, forming clusters, which are very much dependent on the particular process and machinery used, the type of raw material and machine settings (Haldermann and Keller 1992). It is worth noting, that most contaminants remain intact during the opening and cleaning stages in the blowroom, but then become fragmented later.

Furthermore, although some contaminants are removed during the carding and combing processes (Ray and Chatterjee 2001, van der Sluijs, Freijah et al. 2017a, van der Sluijs, Freijah et al. 2017b), the large majority are severely fragmented during carding, mainly due to the action of the revolving flats (Walraf 2000, Faerber, Leder et al. 2010, Faerber, Leder et al. 2010, van der Sluijs and Freijah 2016). These smaller pieces and fragments can remain largely undetected, only becoming noticeable in subsequent processing stages, quite late in the conversion process. This can lead to drafting issues during drawing, roving, and spinning, resulting in end-breakages during the roving and spinning processes, or more costly, in the worst case, it may only be detected once the finished fabric or garment is inspected before sale. It has also been stated, that some 20% of machine stops during sectional warping are caused by foreign fibres (Schlapfer 2008).

PRE-FARM GATE ACTIONS

The first, and most, logical step to address the problem of contamination, is to prevent/avoid or minimize the contamination entering the production process, particularly during growing and harvesting, through the appropriate farm management and associated practices. This can be achieved by appropriate educational programs to growers, harvesters and ginners that provide information on preventing, or at least minimizing, contamination of seed-cotton and lint in the field, up to ginning. These programs need to be regularly updated and presented to ensure that awareness is kept high and that the programs include the latest developments in growing, harvesting, and ginning technologies and practices. The key message in these campaigns should be that negative reputations around contamination can lead to huge losses to the country/region concerned (Blomquist 1997, Simpson 1998, Jordan 2004, Anon 2006, Anon 2016).

A suggested method, but which is perhaps less practical for large cotton fields, is the manual removal of plastic and other contaminating debris prior to harvest (Potter 2015, Haney and Byler 2017). The detection of plastics, by either infrared or ultraviolet light devices mounted on a mechanical harvester, has also been suggested (Whitelock, Byler et al. 2017, Whitelock, Pelletier et al. 2018). Other suggestions, perhaps more applicable to less developed countries, include (Basu 2003, Vijayshankar 2006a, Narkhedkar and Lavate 2011, Zhou 2017);

- Use picking bags made of grey or white cotton.
- Manual sorting of seed-cotton for contaminants prior to ginning and during feeding into the gin.
- Ginning under own supervision.
- Avoid HDPE and Hessian cloth for transportation of waste.
- Provide all workers with white clothing as well as caps and gloves.
- Place the picked cotton on cotton cloth while storing and transporting to the gin.

DETECTION AND REMOVAL AT THE GIN

In some instances, the upgrading and modernization of the gin, in terms of automation, the inclusion of modern cleaners and formulation and implementation of standard work practices, could contribute to the reduction of contamination. This is especially true for hand-picked cotton and in countries where labour costs are comparatively low, with gins employing large numbers of people to feed and operate the gin (Garde, Shah et al. 1996, Pavaskar and Pavaskar 2016, Rajpal 2016)

Contamination detection and removal systems, developed for spinning mills, have been applied in gins since the early 2000s. Nevertheless, to date, despite the successful application in Greece (Nassiou and Buchmann 2005), the systems, or the sensors they employ, do not perform well in the high volume and physically harsh ginning environments (Krajewski and Gordon 2014). Moreover, there is currently no immediate incentive, financial or otherwise, to the grower or ginner, to avoid and minimize contamination in baled cotton, despite the poor reputation and subsequent problems it causes (Kiechl 2004, Faerber, Leder et al. 2010). Furthermore, there is a large cost associated with adapting the systems, designed for spinning mill conditions, to cope with the conditions in a gin (Krajewski and Gordon 2014). It has been stated that cleaning equipment installed in modern gins can potentially remove large contaminants that are mixed in with seed-cotton (Nassiou and Buchmann 2005, Sharma 2014).

This seems to be the case in India where a number of gins have installed these systems with a 40 to 45% cleaning efficiency (Mudhuri and Shah 2014). A number of studies were conducted in the US during 2015 and 2016, to determine the efficiency of the ginning process in removing plastic sheet material of different types and sizes. These studies showed that cylinder-type cleaners (rotating cylinders with spikes to convey seed-cotton across grid bars) removed some 10% of plastic contaminants, while extractor-type cleaners (mainly the stick machine, where rotating saws hold the cotton while centrifugal force removes larger foreign matter such as burs and sticks), removed 56% of plastic with 17% found in the lint, the level of removal depending upon the type and size of the plastic, as well as on airflow and processing rates (Byler, Boykin et al. 2013, Hardin, Byler et al. 2015, van der Sluijs and Krajewski 2015, Hardin and Byler 2016).

From the above, it is clear that it is preferable, if not imperative, to avoid contaminants entering the ginning process in the first place and as such one solution has been to install a camera in the module feeder that automatically detects and alerts gin operators to the presence of large pieces of contamination caught on the module beaters (van der Sluijs and Krajewski 2015, Whitelock, Pelletier et al. 2018). Further research in this area is continuing, with various systems for the detection of plastic in seed-cotton being investigated, including using ion mobility, as well as ultraviolet fluorescence, visible and near infrared and short wave infrared (Funk 2008, Funk, Eicema et al. 2008, Baker, Rayson et al. 2015, Jiang, Whitelock et al. 2016, Whitelock, Armijo et al. 2017, Whitelock, Byler et al. 2017).

DECTION AND REMOVAL PRIOR TO SPINNING

As contamination represents a significant cost to spinning mills, various methods, ranging from contract farming to manual removal to detection and removal by instrument or machine, of eliminating or minimizing contamination, have been implemented, particularly in mills using cotton from different origins. In countries where labour costs are comparatively low, mills will often employ large numbers of people to patrol the bale laydown and remove contamination from the bales before the cotton is fed into the blowroom line, by the bale opener. It has been stated that this manual, and labour intensive, method removes some 40 to 45% of contaminants (Ray and Chatterjee 2001).

Several spinning mills manually inspect every bale of cotton and remove contamination before the bale is processed. This manual sorting is either done directly from the bale or the bale is first opened using a bale opener, with a spiked lattice, prior to manual sorting. Manual sorting is, however, very time consuming and labour intensive and, depending on the cost of labour and level of contamination, can add between 3.1 and 4.4 US cents/kg to the cost of the lint (van der Sluijs, Shankar et al. 2004a, van der Sluijs, Shankar et al. 2004b, Vijayshankar 2006a, Vijayshankar 2006b, Hamilton, Thoney et al. 2012), with the cleaning efficiency ranging from 55 to

70% (Schlichter and Loesbrock 1997, Ray and Chatterjee 2001, Mudhuri and Shah 2014).

Although manual intervention is helpful, spinning mills, that employ staff to manually remove contaminants, have come to realize, that in general, only relatively large pieces of contaminants, e.g. larger than 1 cm^2, are removed in this way (Furter 2006). Furthermore, the manual removal of contaminants is costly, time consuming, tedious, and prone to human error. The process is also very harsh on the hands and eyes, of the mostly female staff, and in most cases the work environment is uncomfortable with no or very little ergonomic considerations. Hence, these mills also invest in systems to automatically detect and remove contaminants. It was estimated that up to 2004, the installation of foreign matter detectors in spinning mills cost the industry in excess of $US150 million (Strolz 2002, Balamurugan 2003, Patodia 2003, Jordan 2004, Strolz 2004). It has been stated that, excluding yarn clearers, spinning mills had, since 1990, invested over $US500 million on systems to detect and remove contaminants in cotton (Faerber and Leder 2016). At an average cost of $US250,000 to $US500,000 per unit, this would increase the cost per bale of cotton by between $US5 and $US10 (Schlichter and Loesbrock 1997, Potter 2015).

Contamination detection and removal systems installed in the blowroom, prior to carding, are common, and form a critical component of the blowroom, with these systems normally installed at the beginning of the blowroom line, after coarse cleaning and initial opening of the fibre, and before the final cleaning stage, although a number of spinning mills have also installed a second machine at the end of the blowroom line (Oxenham 2000, Balamurugan 2003, Anon 2011). The first of these systems became available on the market in the early 1990s, with current systems, able to detect contaminants by means of using acoustic, optical and colour sensors.

These can, depending on the system, detect coloured, white, colourless, and even transparent fibres as the material passes through a viewing chamber after initial opening and before the final cleaning stage before carding. When a contaminant is detected, it is measured (registered) and then pneumatically removed via an alternate material flow outlet (Balamurugan 2003). Despite the fact that there are estimated to be over 5000 contamination detection and removal systems installed worldwide (van der Sluijs 2009, Faerber, Leder et al. 2010, Faerber, Leder et al. 2010), they continue to be rather expensive and require highly skilled technicians. There are also issues with their capacity, as well as the amount of good fibre that is extracted when contaminants are ejected (Schlichter and Loesbrock 1997, Van Nimmen and van Langenhove 1998, Furter 2006, Anon 2007), with older systems removing 100-120 kg and newer systems 30-40 kg per day of good fibre (Anon 2016).

In 2004 it was reported that 25% of the global cotton consumption was processed through contamination detection and removal systems installed in the blowroom (Strolz 2004), with the present authors estimating that up to 80% of all cotton currently consumed globally is processed through these systems. It has, however, been stated that these systems remove only around 60 to 75% of contaminants, this being dependent on the position of the system (at the beginning or end of blowroom line), degree to which the fibre is opened prior to detection, the size and colour of the contaminants, the production rate and the possible number of air blasts per hour, (by pneumatic valves), to remove the contaminants (Blomquist 1997, Schlichter and Loesbrock 1997, Van Nimmen and van Langenhove 1998, Schoeller and Blum 2000, Walraf 2000, Balamurugan 2003, Spinner 2004, Vijayshankar 2006a, Vijayshankar 2006b, Anon 2007, Rufo and Speich 2010, Narkhedkar and Lavate 2011).

In addition, to the foreign matter detectors installed in the blowroom, there are devices on the market that can be added to the creels of drawing and lapping machines, which detect foreign fibres (of a different colour) and stop the machine for removal of the contaminant, by the operator (van Langenhove and Kiekens 2000, Basu 2003, Hamilton, Thoney et al. 2012, Mudhuri and Shah 2014, Haney and Byler 2017).

DETECTION AND REMOVAL DURING SPINNING

Traditionally, electronic (optical or capacitance based) yarn clearers (installed on winding and spinning machines, such as rotor and air-jet machines) were used to detect and remove unwanted and objectionable faults from yarn, e.g., slubs, thin and thick places. Since 1990 modern clearers are also able to detect and remove foreign fibres from yarn before it is wound onto packages. The clearers, installed mainly on winding machines, are now sensitive enough to remove fibrous material, ranging from 1 cm^2 down to 0.001 cm^2 in size, and are therefore considered to be the most reliable for contamination detection and removal (Walraf 2000, Basu 2003). In 2006, 75% of yarn clearers, installed on winding machines worldwide (excluding China), had foreign fibre detectors fitted (Furter 2006). The actual number of such installations will be greater today, given the modernization of the Chinese spinning industry. The types of contamination removed, and the efficiency of their removal, depend on the sensors employed and the specific yarns they monitor. The disadvantage of these systems is their cost and sensitivity to a large number of contaminants, which, in extreme cases, can result in loss of production and increased waste and processing and labour costs, as well as in a reduction in yarn quality, due to increased splices and, in some instances knots, due to clearer cuts (Schlichter and Loesbrock 1997, Van Nimmen and van Langenhove 1998, Schoeller and Blum 2000, Walraf 2000, Ray and Chatterjee 2001, Hamilton, Thoney et al. 2012).

These clearers can also be installed on modern, high production spinning machines, such as air-jet and rotor spinning machines. Nevertheless, to avoid a dramatic drop in efficiency, and yarn strength due to splicing and piercings, these clearers need to be set to remove only the major contaminants (Walraf 2000, Furter 2006). It was estimated that in 2008, only 20% of the yarns spun on the rotor spinning machine were cleared using yarn clearers that detect and remove foreign fibres (van der Sluijs 2009). This number would be greater today, given the modernization and installation of new rotor spinning machines worldwide. A study conducted on rotor spinning showed that high rotor speeds (>100, 000 rpm), smaller rotors (< 36 mm) and low yarn counts (<25 tex) are more susceptible to foreign fibres (Fabian 1986).

Spinners have also stated that yarn clearing systems only remove some 70 to 85% of contaminants (Schoeller and Blum 2000, Ray and Chatterjee 2001, Vijayshankar 2006a, Vijayshankar 2006b, Anon 2007). From a commercial study, conducted by Uster® Technologies AG, it was concluded that a low degree of contamination in ring-spun combed cotton yarns was 10 fibres/100 km, and for carded yarns 20 fibres/100 km, and, resulting from this, the first Uster® Statistics for foreign fibre levels were drawn up in 2006 (Furter 2006).

Modern yarn clearing and monitoring systems, on winding and rotor spinning machines, and the Uster® Classimat yarn classification system can provide information on the type and number of foreign fibres, which assist in determining the clearer settings and also to determine the efficiency of their removal (Kretzschmar and Furter 2008, Sharma 2013).

In order to avoid or minimize any potential claims due to contamination, spinning mills, especially those that produce high quality fine combed yarns, will often, install detection and removal systems in the blowroom and on their spinning and winding machines. This being the most effective way to eliminate foreign fibres without sacrificing production efficiencies (Schlichter and Loesbrock 1997). One study showed that the installation of a modern blowroom detection and removal system and yarn clearers on winding machines led to a 54% reduction in polypropylene and foreign fibre cuts (Anon 2016).

DETECTION AND REMOVAL POST SPINNING

Although there is a possibility of removing contaminants manually from the fabric, this is very time consuming and expensive, being largely manual. In 1995 it was estimated that the associated inspection and removal costs for fabrics were some $US4.00/100 metres, a similar cost being arrived at in 2006 (Frey 1995, Furter 2006). The difficulty of removing the contaminant, without damaging the fabric, depends upon several factors, such as fabric structure and compactness and yarn twist. For example, contaminants cannot easily be removed from knitted fabrics, as this is likely to cause holes, while in a woven fabric it is generally very difficult to remove contaminants present in the warp direction, due to the presence of size (van der Sluijs 2009).

Ultra Violet lights can also be installed in the yarn packing and inspection departments to detect chemical/oily substances and foreign fibres, such as polyester, that fluoresce (van der Sluijs 2009). Chemical treatment, such as bleaching/scouring, in preparation for dyeing can sometimes reduce the problem of contamination, depending upon the nature of the contaminants, but adds further costs, which are not always acceptable. This option may, however, be phased out, due to environmental legislation prohibiting aggressive bleaching, for example with chlorine (Schoeller and Blum 2000).

There is no doubt that all the methods and approaches discussed reduce the risk of contamination related claims but do not guarantee the yarn or fabric produced will be totally free of contamination. Added to this, is the fact that there are no international standards for acceptable levels and size of contaminants in fabrics (Furter 2006).

CONCLUSION

The problem of contamination in cotton has not been satisfactorily resolved, and it remains a serious issue. The actual negative economic, processing, and quality impact of such contamination depends on the nature of the contaminant, with plastic or fibrous contaminants particularly problematic. Although various automatic detection and removal systems have been developed and installed, at various stages of the cotton production pipeline, these tend to be expensive and are not 100% effective.

There can be little doubt that by far the most effective and lasting way of dealing with the problem of contamination is to prevent its occurrence at source. This would require regular, and continuously updated, programs to inform and educate growers, harvesters (hand and machine), ginners and cotton mill processing staff on the damaging effect of cotton contamination, how and where it occurs, and how to combat it. A ‘second line of defence’ remains that of detection and elimination at the various stages of the cotton processing pipeline, and the research efforts and continuous advancement in sensor and associated technologies will no doubt lead to new and more effective systems. Nevertheless, it is unlikely that these will ever lead to a perfect solution to the problem, avoiding contamination at source being the only completely effective and sustainable solution.

ACKNOWLEDGEMENTS

This paper was adapted from ‘Cotton Contamination-A review and Update on the Current Situation’- published by The Textile Institute as a Textile Progress 49(3): 137-171 authored by M.H.J van der Sluijs and L. Hunter (2017).

REFERENCES

Anon (1909). The Sixth International Congress. The International Cotton Federation. Milan, Italy: 384.
Anon (2006). "Cotton Contamination and its Elimination: Status Report." The ICAC Recorder 24(1): 9-14.
Anon (2007). "Cotton Exporter's Guide." International Trade Centre SITC 263: 365.
Anon (2008). "Production and Marketing of Uncontaminated Cotton in Mali." ICAC/CFC: 28.
Anon (2011). "State-of-the-art Foreign Matter Detection." Melliand International 17(1): 19.
Anon (2016). "Prevent Lint Contamination." National Cotton Council of America: 3.
Anon (2016). "Stepping up to Total Contamination Control." The Textile Magazine 57(11): 2.

Anon (2017). "Cotton Contamination Surveys 1989-2016." International Textile Manufacturerrs Federation: 279.

Baker, K., G. Rayson, W. B. Jiang, D. Whitelock, E. Hughs, M. Pelletier and R. Byler (2015). Detection of Plastic and Oily Contamination in Seed Cotton at the Gin using Infra-Red. Beltwide Cotton Conference. San Antonio,TX: 981-989.

Balamurugan, S. (2003). "Foreign fibre contamination in cotton Premier Fibre Eye – the right choice." Asian Textile Journal 13: 69.

Basu, A. (2003). "Contamination in Cotton Fibres and its Removal." Asian Textile Journal: 103-106.

Biermann, I. (2018). Contamination Control in Spinning. International Cotton Conference. Bremen, Germany: 25.

Blomquist, G. (1997). We can stop Contamination-This is how to do it. Beltwide Cotton Conference. New Orleans, LN: 688-689.

Byler, R., J. C. Boykin and R. G. Hardin (2013). Removal of Plastic Sheet Material with normal Cotton Ginning Equipment. Beltwide Cotton Conference. San Antonio, TX: 676-685.

Estur, G. (2008). Quality and Marketing of Cotton Lint in Africa. Africa Region Working Paper Series No.121. Washington, D.C., World Bank: 82.

Fabian, K. L. (1986). "Foreign Fibres- a Problem in Rotor Spinning." Schlafhorst Documentation(18): 10.

Faerber, C. and A. Leder (2016). Progress in Detecting and Removing Cotton Contaminants in Spinning. International Cotton Conference. Bremen, Germany: 57.

Faerber, C., A. Leder and G. Engels (2010). A Modular Solution to Combat the Foreign Matter Problem in Ginning and Spinning. International Cotton Conference. Bremen, Germany: 243-252.

Faerber, C., A. Leder and G. Engels (2010). "A Modular Solution to Combat the Foreign Matter Problem in Ginning and Spinning." Melliand International 16(3): 101-102.

Frey, F. H. (1995). "Foreign matter in the blow room: No longer a problem?" Melliand International 1: 16-18

Funk, P. A. (2008). Detecting Plastics in Seedcotton. Beltwide Cotton Conference. Nashville, TN: 620-624.

Funk, P. A., G. A. Eicema, C. R. White and W. White (2008). "Laboratory Detection of Plastics in Seedcotton with Ion Mobility Spectrometry." Journal of Cotton Science 12(3): 237-245.

Furter, R. (2006). "Experience with Foreign Matter Removal Systems for Cotton." Uster Technologies AG (Application Report SE594): 32.

Garde, A. R., P. H. Shah and D. I. Patel (1996). "Technology for Producing Clean and Contamination - free Cotton Bales." Journal of the Institute of Engineers, India 77(1): 14-17.

Gordon, S. G., M. H. J. van der Sluijs and M. W. Prins (2004). "Quality Issues for Australian Cotton from a Mill Perspective." Australian Cotton Cooperative Research Centre: 60.

Haldermann, P. and R. Keller (1992). "Characteristics and Cleaning of Foreign Matter in Short-Fiber Yarns." Pakistan Textile Journal 41(4): 33-35.

Hamai, A. (2003). The Problems in International Trade caused by Insufficient Knowledge about Cotton Quality. 62 nd Plenary Session of the ICAC. Gedansk, Poland: 12.
Hamilton, B. J., K. A. Thoney and W. Oxenham (2012). "Measurement & Control of Foreign Matter in Cotton Spinning: A Review'." The Indian Textile Journal 122(7): 48-56.
Haney, B. and R. Byler (2017). Plastic Impurities Found in Cotton. Beltwide Cotton Conference. Dallas, TX: 332-338.
Hardin, R. G. and R. Byler (2016). "Removal of Sheet Plastic Materials from Seed Cotton using a Cylinder Cleaner." Journal of Cotton Science 20(4): 375-385.
Hardin, R. G., R. Byler and C. D. Delhom (2015). Removal of Plastic Materials using Adjustments and Revisions to Standard Seed Cotton Cleaning Equipment- Progress Report. Beltwide Cotton Conference. San Antonio, TX: 973-980.
Herber, D., W. D. Mayfield, C. Howard and W. F. Lalor (1990). "Contamination: An Industrywide Issue." Physiology Today 2(1): 4.
Hunter, L. (1989). "Cotton Contamination: A Review." Tex Report(2): 21.
Jiang, W. B., D. Whitelock, G. Rayson and E. Hughs (2016). Low-Resolution Mid-Infrared Reflection Analysis for Discernment of Contaminants in Seed Cotton. Beltwide Cotton Conference. New Orleans, LA: 657.
Jordan, J. G. (2004). Lint Contamination- A Serious Threat to U.S. Cotton. Beltwide Cotton Conference. San Antonio, TX: 38-39.
Kiechl, W. (2004). Is there an ideal cleaning point for Textile Contaminants? International Cotton Conference. Bremen, Germany: 143-149.
Knappe, M. (2014) "African Cotton: Reducing Contamination will Generate Premiums." Cotton Grower, 1.
Krajewski, A. and S. G. Gordon (2014). Cotton Contamination Detection Sensors. Final Report. Narrabri, NSW, Cotton Research and Development Corporation: 17.
Kretzschmar, S. D. and R. Furter (2008). "Analysis of Yarn by Sophisticated Classifying System." Uster Technologies AG, (Application Report SE 620): 16.
Mudhuri, V. and H. R. Shah (2014). "Cotton Contamination - Its Sources & Remedial Measures." Textile Industry of India 53(5): 15-21.
Narkhedkar, R. N. and S. S. Lavate (2011). "Cotton Contamination Removal Systems in Blowroom." The Indian Textile Journal 121(9): 87-92.
Nassiou, T. and B. Buchmann (2005). "Cut Cotton Contamination." Cotton International 3: 18.
Oxenham, W. (2000). "Preparing For Change." ATI 29(4): 59-62.
Patodia, B. K. (2003). Contamination - A Pain in the neck of Spinners. 62nd Plenary Session of the ICAC Gdansk, Poland: 12.
Pavaskar, M. and R. Pavaskar (2016). "Improving Cotton Quality." Cotton Statistics & News (34): 9-10.
Pavaskar, M. and R. Pavaskar (2016). "Improving Cotton Quality." Cotton Statistics & News (35): 8-10.
Potter, B. (2015). "7 Steps to a Contamination -Free Harvest." Farm Journal: 1.
Rajpal, S. (2016). "Contamination of Cotton: Sources and Remedies." Cotton Statistics & News 34(22): 1-4.
Ray, S. and B. Chatterjee (2001). "A Review of Different Measures to Eliminate Contamination from Cotton." Journal of the Textile Association 72(1): 5-8.

Rufo, S. and H. Speich (2010). "Magic Eye M1: This Magic Eye Sees Everything." Rieter Link 22(56): 15.
Schlapfer, W. (2008). "Yarn Detective." Textile Month (2): 26.
Schlichter, S. and P. Loesbrock (1997). Foreign Particles in Cotton - Origin of Contamination and Removal in Processing. Beltwide Cotton Conference. Memohis,TN: 673-678.
Schoeller, P. and F. Blum (2000). Contamination –The Spinners Perspective. International Cotton Conference. Bremen, Germany: 46-55.
Sharma, K. (2013). "Contamination-controlled Cotton & Yarn." The Indian Textile Journal 123(11): 34-41.
Sharma, M. K. (2014). Contamination, Trash and Moisture Control in Ginning & Pressing Factories. Cotton India 2014. Nagpur, India: 5.
Simpson, S. (1998). Contamination: Educating the Ginner and Grower. Beltwide Cotton Conference. San Diego,CA: 461-463.
Spinner, H. (2004). "Chances of Cleaning White Contamination in the Preparation Line." Textile Asia 35(9): 35-38.
Strolz, H. M. (1998). ITMF Cotton Contamination Survey 1997. International Cotton Conference. Bremen, Germany: 21-25.
Strolz, H. M. (2002). ITMF Cotton Contamination Survey 2001. International Cotton Conference. Bremen, Germany: 41-45.
Strolz, H. M. (2004). "A fresh look at Cotton Contamination." Asian Textile Journal 13(5): 29-32.
Thilagavathi, G. and T. Karthik (2013). Control of Wastes in Spinning. Process Control and Yarn Quality in Spinning. New Delhi, India, Woodhead Publishing India Pvt. Ltd: 69-140.
van der Sluijs, M. H. J. (2007a). "Contamination in Australian cotton." Australian Cotton Grower 28(2): 48-50.
van der Sluijs, M. H. J. (2007b). "Contamination in Australian Cotton " Textile Asia 38(7): 63-66.
van der Sluijs, M. H. J. (2009). "Contamination and its significance to the Australian Cotton Industry." Cotton Catchment and Communities CRC: 36.
van der Sluijs, M. H. J. and M. Freijah (2016). A Preliminary Investigation into the Removal of Plastic Wrap during Ginning and Textile Processing. Beltwide Cotton Conference. New Orleans, LN: 885.
van der Sluijs, M. H. J., M. Freijah and M. Guittet (2017a). Another Look into the Removal of Plastic Wrap during Textile Processing. Beltwide Cotton Conference. Dallas, TX.
van der Sluijs, M. H. J., M. Freijah and M. Guittet (2017b). The Removal of Plastic Wrap during Processing. Australian Cotton Research Conference. Canberra, ACT: S77.
van der Sluijs, M. H. J. and P. D. Johnson (2011). "Determination of the Perceptions and Needs of Mills that Purchase and Process Australian Cotton." CSIRO: 128.
van der Sluijs, M. H. J. and A. Krajewski (2015). Contamination Detection using Module Hood Feeder Sensors. Beltwide Cotton Conference. San Antonio,TX: 990-998.
van der Sluijs, M. H. J., V. Shankar and S. G. Gordon (2004a). "Contamination on the increase." Australian Cotton Grower 25(1): 46-52.

van der Sluijs, M. H. J., V. Shankar and S. G. Gordon (2004b). "Contamination, its Causes and Cure." Textile Asia 35(2): 57-59.

van Langenhove, L. and P. Kiekens (2000). Contamination of Cotton Fibres: How to solve the Problem. International Cotton Conference. Bremen, Germany: 56-60.

Van Nimmen, E. and L. van Langenhove (1998). Spinners Tools to Deal with Cotton Contamination. Beltwide Cotton Conference. San Diego, CA: 723-725.

Vijayshankar, M. (2006a). Extraneous Contamination in Raw Cotton Bales – A Nightmare to Spinners. International Cotton Conference. Bremen, Germany: 61-76.

Vijayshankar, M. (2006b). Processing Your Product - Using Australian Cotton'. 13th Australian Cotton Conference. Broadbeach, Queensland: 8.

Walraf, E. (2000). "Foreign Matter - Quality Problem No.1." Rieter Link 12(30): 10-12.

Whitelock, D., C. Armijo, E. Hughs, S. Delwiche and M. Kim (2017). Continued Work to develop a Low-cost Sensor to Detect Plastic Contamination in Seed Cotton at the Gin. Beltwide Coton Conference. Dallas, TX: 389-397.

Whitelock, D., R. Byler, M. Pelletier and A. Thomasson (2017). What Research is happening to help Prevent Contamination of U.S. Cotton? Beltwide Cotton Conference. Dallas, TX: 435-440.

Whitelock, D., M. Pelletier, A. Thomasson, M. Buser, B. Xu, C. D. Delhom and R. G. Hardin (2018). Current University and USDA Lab Cotton Contamination Research. Beltwide Cotton Conference. San Antonio, TX: 516-520.

Zhou, Y. (2017). "Opinions about Cotton Contamination." ITMF Spinners Committee: 6.