FOREIGN PARTICLES IN COTTON - ORIGIN OF CONTAMINATION AND POSSIBILITIES OF DETECTION AND REMOVAL IN PROCESSING

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Abstract

The contamination of cotton with foreign parts has become an increasing problem for the spinning industry in nearly all parts of the world. The complexity of forms, colors, surface structures, type and frequency of these parts calls for a highly sophisticated approach to solve this problem.

Based on the application of image analyzing techniques it was possible to develop a highly effective machine for the detection and separation of foreign parts in the blowroom. The machine is characterized by:

- Separation of fire, metal, and foreign parts in one unit
- Avoidance of additional feeding units or conveyor installations
- Minimal power consumption
- No need of output air and filter capacity
- High throughput quantities
- Simple integration also into existing lines
- Sturdy and virtually maintenance-free design
- Simple operation
- Intelligent and self-learning camera system
- Individual, automatic calibration to the cotton in use
- Possibility of sensitivity adjustment by the customer
- Automatic readjustment of camera and illumination device
- Synchronization with bale opener to improve sensitivity adjustment and to locate badly contaminated bales during the preparation process

First applications of these machines in European spinning mills indicates clearly the possible benefit of such a unit in order to avoid problems with foreign parts in further processing.

The modular design of the machine enables the integration of the foreign part detection and separation unit in addition to the anyway necessary safety functions of metal and fire protection when the use of heavily contaminated cottons or international competition in markets with higher demands on foreign part freedom calls for the application of such a unit.

Introduction

The contamination of cotton with foreign parts is actually an old problem which has confronted the cotton processing industry from the beginning. Higher demands on the quality of the end products, and increasing appearance of such contamination in certain growing regions, however, have resulted during the last years in a strongly growing request for effective, automatic removal in the spinning mill. This problem is especially apparent right now in the European textile industry, since the cottons processed there (mainly from Asian and East-European growing areas) are heavily contaminated with foreign particles.

The problem however is quite complex and needs special attention in development to create a solution that is effective enough to improve the situation in the spinning mill. The situation can be covered only briefly here:

- The spinners' problems with damages caused by foreign particles are extremely dependent on the individual application with regard to spinning method, fabric formation method and type of end use. Thus a foil part made of PP doesn't cause much concern in fabrics that go through thermal stabilizing by a tenter frame. The same part, however, can turn into one of the most dangerous parts for the producer of light knits when it cannot be dyed during the piece-dyeing process, and prior to that cannot be detected because it is of the same color as the raw material. Fig. 1 shows an example of such a particle found in a finished light color T-shirt of a major US-producer. A similar example is shown in Fig. 2 in a woven fabric.

- The cottons are contaminated with foreign parts to various degrees. As can be seen on the world map shown in Fig. 3, the contamination is concentrated in certain regions, whereas only slight contamination occur in other regions. The US. is presently a growing area with only slight contamination.

- The type and frequency of the foreign parts found in cotton also varies strongly. Fig. 4 shows for example parts which have been found at various customers. During our many years of experience with foreign parts we have learned that actually there is nothing that hasn't been found in cotton before. The colors range from transparent to white-yellow to black, as well as any color combination in-between, like printed foils. Basically it is much easier to make a definition by using the opposite: anything that is not cotton can be considered an interfering foreign part which is not being removed like trash during the normal cleaning process. The parts are also by large unlimited in regard to size.

- It also needs to be considered that foreign parts appear in cotton only in extremely small percentages, and are therefore statistically an extremely rare occurrence which makes detection more difficult. A large percentage of foreign particles is removed during the blowroom process anyway. We were able to prove this impressively during a basic trial. Already 5 years ago we artificially "contaminated" a cotton bale with 100 foreign particles in

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our technical department. We were able to find 95 parts again in the waste chambers of the cleaners and the card, which had been separated in a "natural" way. An effective foreign parts detection must therefore be measured by its capability to significantly reduce the remaining 5 % of foreign particles if it is to be successful on the market. This puts extremely high requirements on the detection rate of the applied detection system.

• Furthermore it is difficult to control such a device because only the end product tells to which degree the foreign part detection was successful. The level of contamination is usually unknown, thus also the controlling effects of the unit.

• Also in regard to the correct location of the foreign part separator in the installation opposing aspects need to be considered: on one hand the parts are easier to be detected while there are of larger size at the beginning of the process. On the other hand, the low opening degree of the cotton makes a detection of foreign parts more difficult. Therefore special measures have to be taken to present the material to the sensors as open as possible in this early stage of processing.

• Another factor that needs to be taken into account is that a foreign part separator should not interfere with the technological process of opening and cleaning. Additional opening units and processing stations should therefore be avoided if at all possible. Besides, it is recommended to integrate all separation-functions, i.e. also metal protection and fire protection into one machine.

The key position, however, is held by the applied detection system which - considering all of the above margins - must possess a good detection capability.

Selection of detection system

Foreign parts differ from the raw material mainly by

color,
form, and
surface structure.

The detection system to be selected should be able to capture as many of these symptoms as possible and to use the combination of these features for separation. In the same way, the capturing of these features must be kept separate from the cotton to be processed because the raw material - depending on origin - also shows differences in the above mentioned characteristics. Cotton possesses various luminance and color values and, according to the degree of opening, has different tuft structures and forms. The detection system that is to take all this into consideration must also be ***intelligent*** and ***self learning.***

These features are not present on mere ***sensor*** solutions (like color sensors), since normally sensors only allow a preset measuring value, respectively a preset combination of measuring values.

Today it is possible to perfectly actualize the demands made on intelligence and learning capability by ***image analyzing.*** By means of the type of design of the illumination device it is possible to capture the color and the surface structure. This way strongly reflecting surfaces, like transparent foil, can be made visible by **reflecting light** that is in noticeable contrast to the cotton tuft that does not possess this ability to reflect. Very dense structures with little translucency can be better detected with **transmitting light**. The effects of controlled application of different illumination in image analyzing can be seen in Fig. 5 for typical foreign parts in cotton. In combination with software tools to detect certain forms of particles the image analyzing systems can be trained to detect all important characteristics of foreign particles.

Another aspect that needs to be taken into consideration when selecting a sensor is the maintenance and calibration intervals. Efficient sensors should be able to recalibrate themselves and be maintained and adjusted by plant personnel.

Description of the SECUROMAT SCF 154

In contrast to other systems, the SCF can be directly integrated into the blowroom line without additional feeding devices or air transport units (like condensers). In front of the device (Fig. 6) the round material transport pipe is transferred to a rectangular channel via a funnel. At the input side of the device spark detectors can be installed, providing fire protection for the installation. A metal detector with high measuring dynamics for detection of even small metal parts is located further down the material flow.

This is followed by the camera units for foreign part detection. Always two cameras are arranged side by side to cover the complete channel width. The camera unit is equipped with a flash and--opposite from it-- a counter flash illumination system to detect foreign parts in the cotton tufts which pass by in high frequency. There is a total of two camera systems, arranged in series, to check the cotton from both sides so that no foreign parts on the backside of the tufts are ignored. At a detection rate of 400 images/s half of the pictures are taken with transmitted light, the other half with reflecting light.

During an automated learning phase, the luminance and structure of the cotton to be processed is studied to enable adjustment to the cotton in use. For this purpose ca. 5000 pictures of the tuft flow are evaluated. Up to 8 materials can be conceived and stored in the calibration memory. This procedure allows a very safe distinction between foreign parts and the processed cotton. Dependent on the extent of the color deviation and the structure as well as size of the

part, a separation - based on the various separation criteria - takes place. The customer can set the sensitivity adjustment on the keyboard individually for each material. The procedure is explained in the following illustration (Fig. 7). The so called material color graph shows the intensity of light absorption in reflecting light (A) versus the light absorption in transmitted light (D). As can be seen from this graph the automatic calibration procedure leads to safer detection of foreign parts by minimizing the description field of cotton through more frequent individual calibration of the raw material.

A recalibration can take place automatically at any time, even after preset intervals. Presently a software is in preparation that makes it possible to synchronize the SCF-detection with the movement of the detacher head of the automatic bale opener BLENDOMAT BDT. This will allow for individual calibration adjustment to the various cottons in the bale laydown which in turn will help to improve the separation safety. In addition it is possible to trace bales that are contaminated and to avoid these bales or origins in the future.

The operation of the device does not require any special knowledge about camera, illumination components, or software and has been deliberately kept simple. There are only the three operation modes: "learning material", "adjusting sensitivity", and "automatic operation". The various separation quantities are recorded separately by the device and can be forwarded to the central control for further evaluation.

The detection systems are followed by a quick separation flap that discharges metal parts, foreign parts, as well as fire. When switching the flap, the suction power in the pipe is maintained, i.e. the air flows back into the pipe via a screen. This screen is designed in such a way that even in case of spark detection it is impossible for a spark to jump through the screen. The whole system is a modular one, allowing selective installation of the three detection systems for sparks, metals, and foreign parts. Thus the possibility exists to adapt the device to contain the individual safety functions specified by the customer. The device doesn't have any output air and therefore has no need for additional filter capacity.

The device is adjusted to the air quantities and speeds required behind the bale opener. The detection can take place up to air speeds of almost 20 m/s. Based on the high transport speed in this device, as compared to other devices with preconnected condenser, the tufts are mostly separated at detection, thereby increasing the separation safety. In connection with the quick-action flap, the separated quantities are small. Depending on production they range between 30 g and 100 g. There is actually no limit on the throughput. The maximum production that is made possible by our automatic bale openers can be handled by the unit. In connection with the foreign part separation there is a production limit of 800 kg/h to achieve an acceptable detection rate.

Fig. 8 shows an example for the integration of the SCF into a typical blowroom installation.

Operational experience and performance profile

Since mid 1995 the device is being tested under real conditions. Since the beginnings of 1996 several units were installed in different parts of Europe with customers who produce very sensitive products in regard to foreign parts content. The effects of the device on further processing were also evident during direct comparisons with other systems.

However, Fig. 9 also shows that it will not be possible to give a 100 % guarantee in regard to separation in the blowroom. Nevertheless, the selected approach has brought about excellent effects on the degree of foreign part freedom.

Due to the high tech components of image analyzing incorporated into the machine the price of this unit is relatively high compared to typical blowroom machinery. Based on figures given to us by our customers concerning the annual damage caused by foreign particles a calculation of the economical benefits of such a machine was carried out. The calculation is based on an average detection rate of 70% (a value that could be proven in mill applications). As can be seen in Fig. 10 an economical benefit could easily be obtained despite the high price of the unit.

Based on the same calculation it can be figured how much the incorporation of a foreign part detector in a blow room line effects the raw material price. Fig. 11 shows that the use of the SECUROMAT SCF increases the raw material price between 0.5 and 1 cts/lbs for typical production ranges applied in blowroom installations. In relation to the possible damages caused by foreign parts this seems to be a relatively low figure for the insurance to be able to process even more contaminated cotton origins, which in fact are priced down often to a much higher extent.

Real life experiences also show that carrying out the separation of foreign parts on the yarn clearer of the spinning and winding machines alone does not represent an effective alternative to the application of foreign part separators in the blowroom. Without such units in the blowroom, losses in regard to efficiency of spinning and winding machines cannot be avoided, and the degree of foreign part freedom is unsatisfactory.

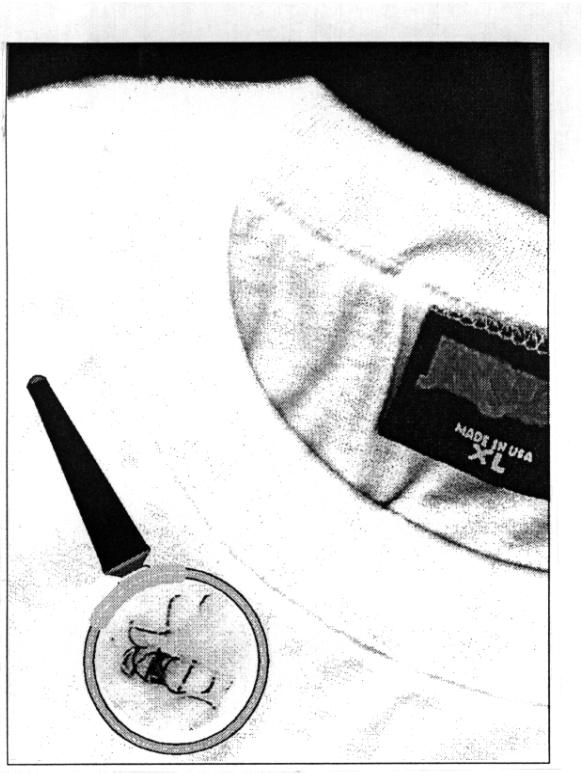

Figure 1: Fibre contamination in a light color T-Shirt

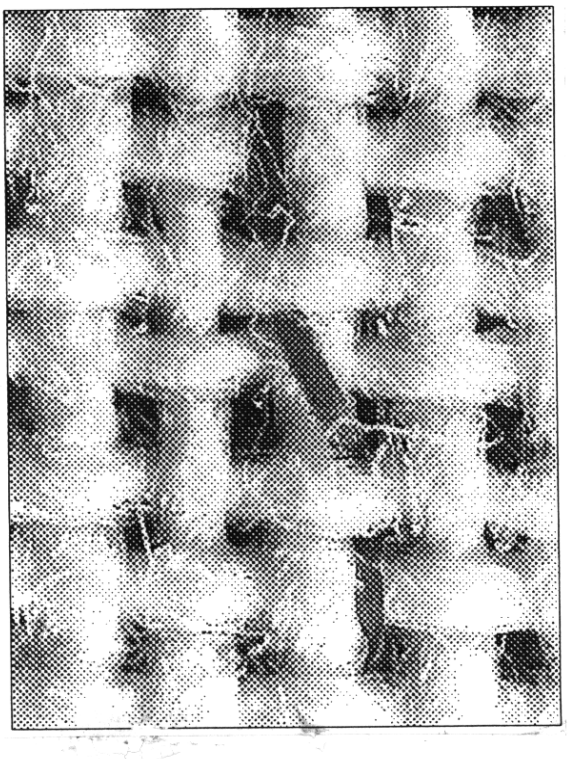

Figure 2. Fibre contamination in a woven fabric

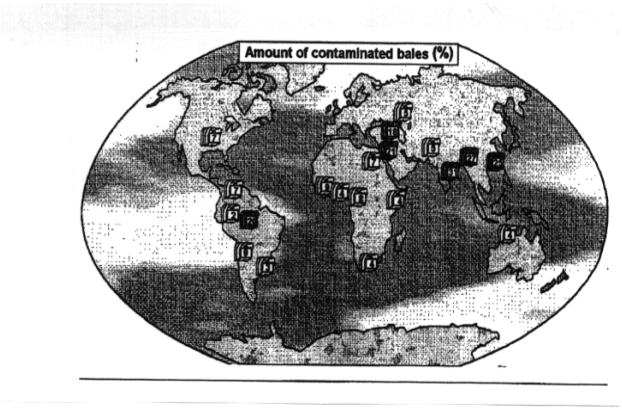

Figure 3. Amount of contaminated bales for different growing regions

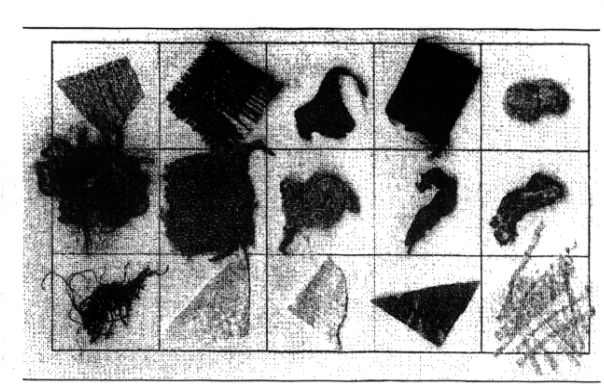

Figure 4. Examples of contaminations

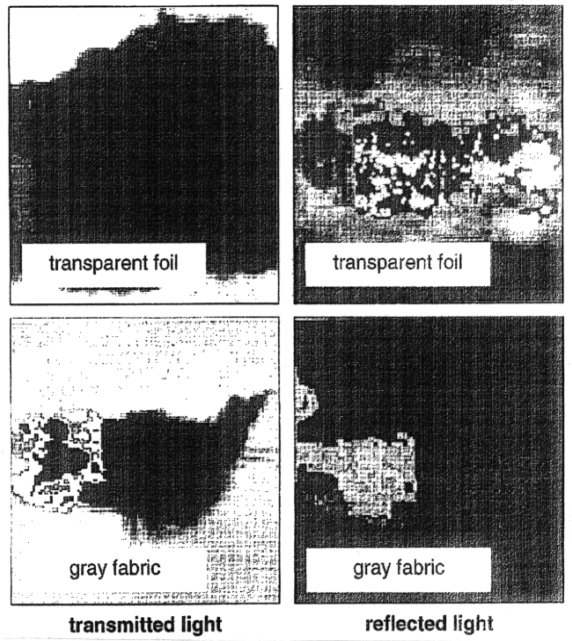

Figure 5. Results of image analyzing in different illumination

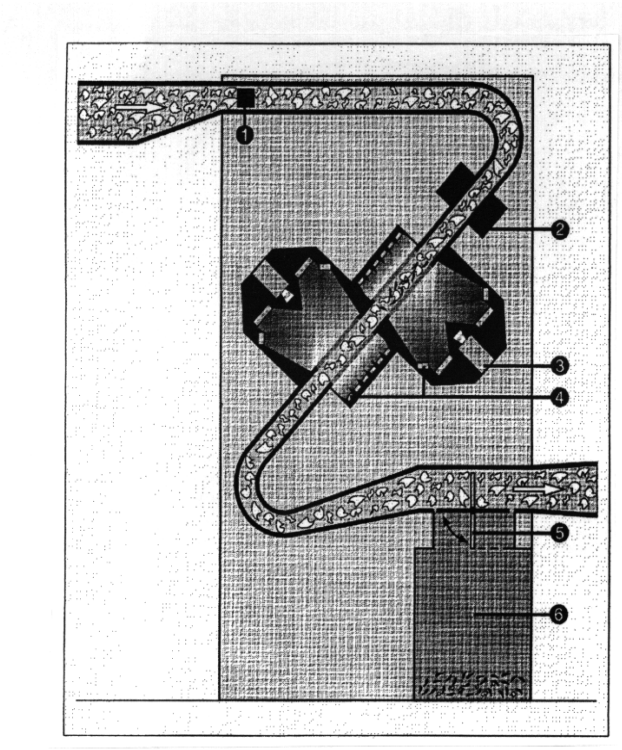

Figure 6. SECUROMAT SCF

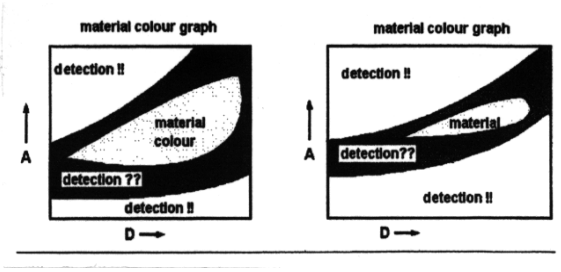

Figure 7. Automatic Calibration Procedure

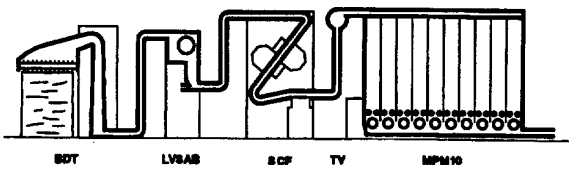

Figure 8. Integration of SECUROMAT SCF in a blowroom line

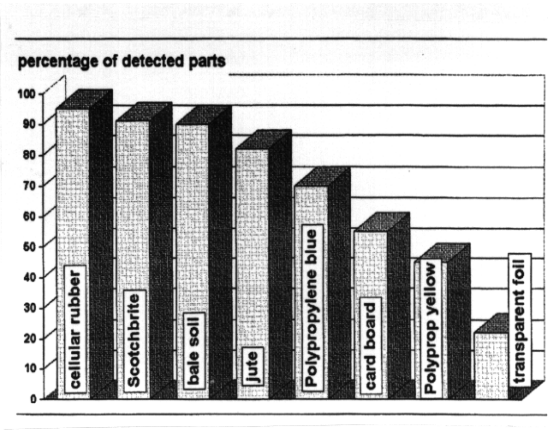

Figure 9. Detection rates of foreign parts by the SECUROMAT SCF

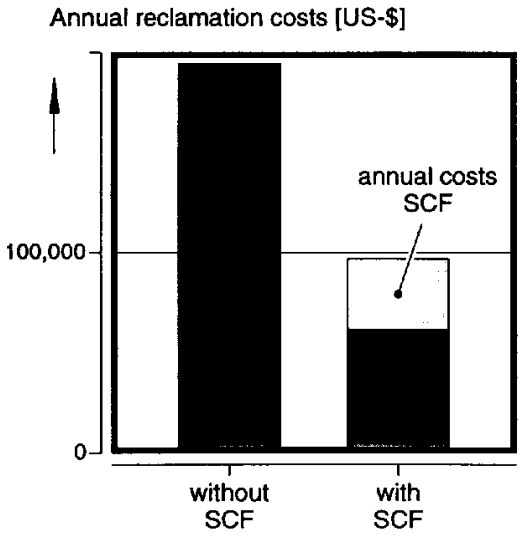

Figure 10. Reduction of damages caused by foreign parts using SECUROMAT SCF

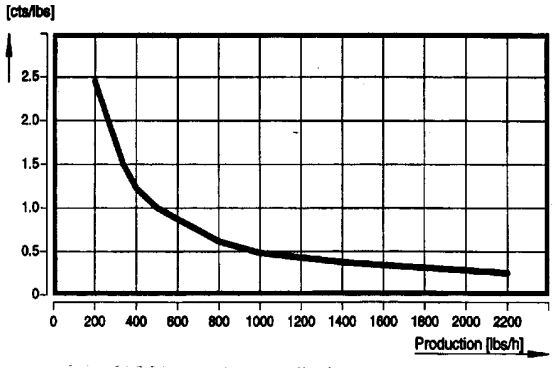

Figure 11. Costs of foreign parts detection in a blowroom line