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Process analysis and improved results in industrial production

Manufacturers of high-quality nonwovens and hygiene laminates are now controlling their entire production with inspection systems. Flaws are detected and marked and the operator is alerted immediately. The raw materials, the process and the finished products are monitored.

Increasingly, inspection systems are becoming indispensable for production lines. On the one hand, the market requires 100% quality control (pharmaceutical, medical, food production etc.), while manufacturers, on the other hand, want to avoid rejects and optimise the production process. While investment costs for production lines are high, manufacturers do not have objective data regarding the quality of laminates and nonwovens.

State of technology

Thanks to technological advances, cutting-edge inspection systems can realistically process data rates up to 400 MHz per camera. Depending on the application, the systems can use CMOS dual line cameras with 2048, 4096 or 8192 pixels or colour line cameras with CMOS sensors for detecting low-contrast flaws. These cameras achieve image rates up to 144 kHz. In a downstream direction, high resolution is possible even at high line speeds.

Interacting with high-quality LED lighting technology, dual line cameras offer the so-called shutter method. The same flaw is captured by the same camera with two different lighting conditions, e.g. in transmission in bright and dark fields or in reflected and transmitted light. This process offers improved detection and classification.

External sensors, such as shrinkage or colour measurements, can be integrated in the inspection systems via interface. This documents LAB colour space values and triggers an alarm in case of deviations.

The modern systems detect surface flaws such as specks/gels, black specks, fish eyes, colour contaminations, thick and thin spots, lamination flaws or insects. At the same time, the system analyses cloudiness. With the images of the flaw, the operator can teach in the flaws and the system can automatically determine the criteria for classification of flaw types.

Flaws and their causes

Today, about 50% of nonwovens are made from pellets – especially in the hygiene and medical markets, with market shares increasing. As inherent flaws of polymers, gels/specks are particularly important here. Specks are small irregularities in the polymer, characterised by their area (size in transmitted light) and their raised profile on the fabric surface.

The common statement “My nonwoven does not have specks/flaws” is a thing of the past. Every nonwoven has specks – due to the production process and the material properties, they are unavoidable. Basically, specks are just a matter of resolution.

Based on experience and estimated from the extrusion process, specks are caused by the following: extrusion line (less than optimal screw geometries, deposits etc.) 20%, raw materials (contamination, adhesions etc.) 25%, production process (wrong temperature parameters, insufficient rinse etc.) 15%, and pellet transport, external and internal (contamination of silo vehicles, PE abrasion etc.) 40%.

For decades, raw material producers have done gel counts for internal standardised quality control. Every hour, 50 samples are automatically taken from the process and transported to an extruder with gel count in a clean room for analysis. The information is transmitted to the process control system.

In online inspections, the resolution for standard applications, e.g. PE or PP productions, is 50 μm. Special applications such as polymers for high-voltage cables work with resolutions up to 5 μm.

Flaw types

Flaw categories include specks, gels, black specks, colour contamination, holes, insects, thick spots, thin spots etc. The different flaw types have different causes and cause different problems for further processing.

Since there is no unified ISO or DIN standard for flaw categorisation and since there are no clear rules for the definition of defects, there can be big differences in the description of a flaw, depending on the perspective of the observer.

Therefore, it is important to be open about this issue and discuss the subject of flaw categorisation and resolution or size detection with suppliers and customers. Increasingly, these measures are becoming a question of a company’s competitive edge.

Typical flaws in the extrusion process include: Speck/gel (non-melted material or adhesions – similar to a drop of water on transparent film), black specks (cracked or burnt material, brown or black), fish eye
Most critical flaws or aspects in nonwovens for hygiene and medical applications are colour contaminations, e. g. caused by droplets of condensation (detection via colour line cameras) and cloudiness analysis with live image of the nonwoven.

**Trailblazer Mondi Gronau**
Mondi Gronau GmbH (formerly Nordenia Gronau GmbH), Gronau, Germany, is considered a pioneer in the field who has realised comprehensive process analysis and integration.

The materials are monitored at-line, the quality of the produced compound is inspected online with lab extruders and camera systems. During extrusion, the cast films are controlled by film inspection systems with implemented alarm thresholds for the machine operator as part of line and process control.

The process also includes external measuring systems, such as colour measurements, which connect to the inspection software via OPC interfaces. Downstream lamination (film strips between two nonwoven panels) is monitored and the applied strips are measured and checked for correct position. This is carried out at production speeds up to 600 m/min. Individual, critical flaws are cut out during post-processing.

**Integration into the corporate network**
The systems are integrated into the in-house production data acquisition system (PDA). With each roll change, the measuring data of the respective roll is saved by roll number and production date on an internal server. In case of complaints, all roll details are available if needed. It also makes it possible for the customer to block certain rolls, if necessary, in order to avoid problems.

The measuring data on the local inspection servers are automatically deleted every six months. That leaves enough time to compare the results with similar past production batches, if the extrusion shows speck problems. Potential causes can be analysed more quickly that way.

The inspection systems are integrated into the production process so that machine operators use them to start up and set the extruders. In case of critical individual mistakes, too many specks or bad roll data, an indicator light warns the operator, who can step in directly.

**The data logger**
The quality management measures were expanded to add data management software that can sort and process measuring data by certain criteria. An overview of all laminate and film types produced in a certain period are available with a mouse click, regardless of the respective production line. Batch, roll or use logs as well as statistical analyses can be generated.

Additional central analysis software can import material and process parameters from the PDA or via an OPC interface (Open Platform Communications). The collected data is connected to the respective quality control/roll note. The long-term goal is the development of an SPC solution (Statistical Process Control).

**Benefits for producers**
The causes of production quality issues must be detected and selected in real time from about 500 features of a highly complex production machine. The results are the basis for improvement suggestions, which need to be generated for the machine operator in order to prevent quality issues.

The extensive network of complex data in the systems of supplier OCS, Optical Control Systems GmbH and the PDA (via intelligent data pre-processing) supports analyses generated from established database structures.

Sophisticated statistical tools from the industrial and research sectors are used for data processing, analysis, modelling and reporting to detect and visualise the abovementioned causes and generate suggestions for improvements.

"Considering trends and statistical key figures, online monitoring is a preventive measure that helps reduce rejects, post-processing and machine downtimes," explained Oliver Hissmann, Dipl.-Oec. MBA (USA), since 2003 Sales Manager at OCS Service GmbH, Witten. “Based on these insights, OCS continues to develop monitoring and alert tools for more machines and add functionalities in order to offer better process monitoring and control.”

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Mondi Gronau GmbH is a leading international manufacturer of different film products. Their portfolio ranges from high-quality printed film packaging and film for automatic packaging to technical films and hygiene components, laminate and labels films to decorative film and flooring film. It is part of the Mondi Group, an international packaging and paper manufacturer with about 25,000 employees in more than 30 countries, mainly in Central Europe, Russia, North America and South Africa. The group’s business units include timber production, cellulose, paper and plastic compounds as well as the development of packaging solutions for the industry and consumer applications. OCS Optical Control Systems GmbH is a manufacturer setting new standards for quality control and inspection in the polymer, film and nonwoven industries.

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