WebFeat

Surface Inspection for Plastic Films

Dr. Schenk Inspection System WebFeat for Plastic Film

An Essential Component for the Quality Assurance and Process Control of Plastic Films

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Inspection systems for web materials have been on the market for over 20 years and have been subject to a constant refinement. The especially rapid evolution of electronic components leads to processing performances and prices inconceivable just a few years ago. This article provides an overview of the inspection technologies available today with special emphasis on the inspection of plastic films.

Plastic Films

Image Acquisition

The foundation of efficient web inspection is to achieve the best possible image acquisition, in other words the highest possible contrast of the defects to be detected. This might sound trivial, but the careful selection of illumination techniques and imaging sensors yield an inspection system design that meets the required specifications with the least possible investment. There are two principal technologies available, CCD-camera scanners and laser scanners.

CCD-Camera Scanners consist of one or multiple line scan cameras, as well as one or multiple illumination techniques. These line scan cameras are comparable with those CCD-chips used in digital photography with the difference being that they consist of a single line of pixels. These lines, with up to 8192 pixels, are exposed and read-out at a very high (up to 78 kHz) frequency. A continuous image of the inspected material is received by moving it perpendicular to the line (*Figure 2*).

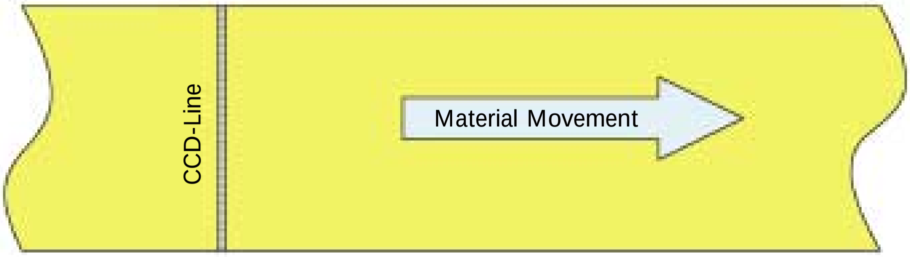

Figure 2: Scanning Principle of Web Inspection

The most important aspect in the design of a successful inspection system is the correct selection of the illumination. As seen in *Figure 3*, the illumination techniques are divided into basic modes: Inspection in transmission (where the camera sees through the material) versus inspection in reflection (where the camera sees the reflection of the material) and inspection in bright-field (where the camera looks directly into the source of light) versus dark-field (where the camera looks past the light source).

Bright-field illumination produces images that are very similar to photographic pictures. Typically this type of illumination is very efficient for light-absorbing defects. Depending on the required imaging quality either diffuse illumination (*Figure 4 and 5*) or beamed illumination (*Figure 6*) with an increased contrast and sensitivity for light-diverting defects (distortions) are used.

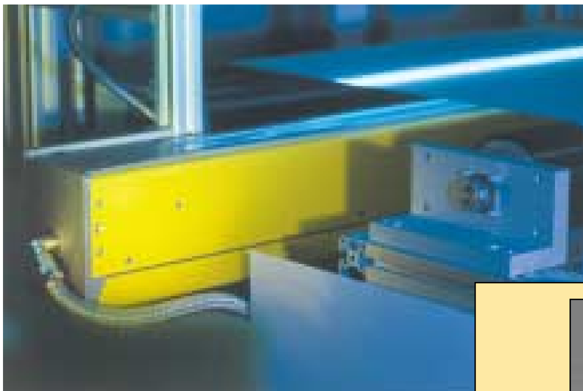

Figure 4: Diffuse Illumination

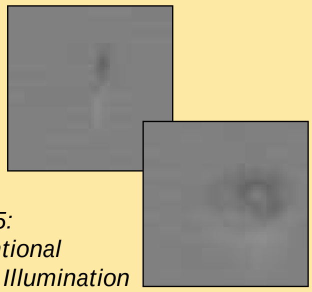

Figure 5: Conventional Diffuse Illumination

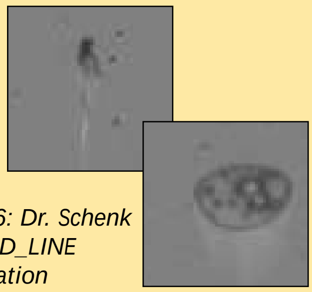

Figure 6: Dr. Schenk BEAMED_LINE Illumination

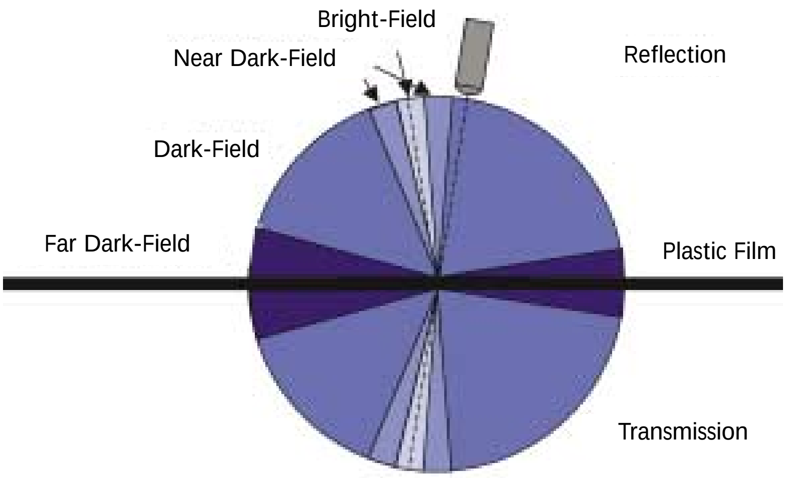

Figure 3: Illumination Modes

Another very efficient lighting method is specially developed dark-field illumination (*Figure 7*) that offers a relatively economical alternative for the detection of typical defects in plastic sheets like gels, contaminates and holes.

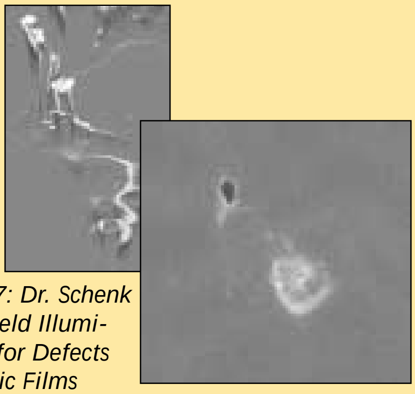

Figure 7: Dr. Schenk Dark-Field Illumination for Defects in Plastic Films

Laser Scanners (*Figure 8*) consist of a laser scanner head in which a laser beam is reflected off a spinning polygon mirror that creates a sweeping (scanning) motion of the laser beam across the web that starts over as it reaches the edge of the web. The picture signal results from a photomultiplier that converts the light energy into an electric current proportional to the received luminous intensity. Depending upon the application, typical maximum scan frequencies are approximately 5-10 kHz.

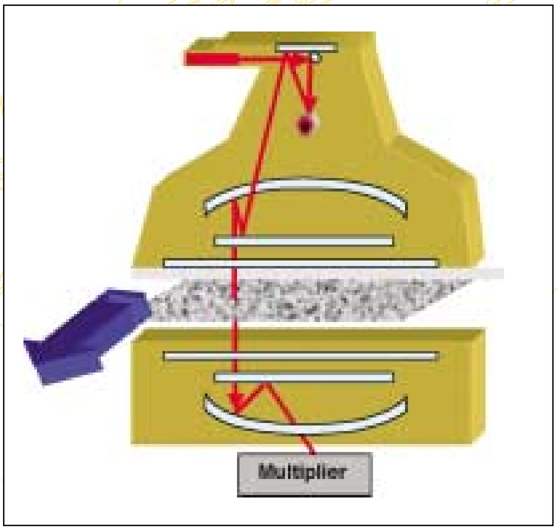

Figure 8: Telecentric Laser Scanner with Mirror Receiver

Laser scanners can represent an economical alternative for plastic foils if multiple optical channels (e.g. bright-field and dark-field in transmission) are needed and the web speed is relatively low.

For those relatively simple laser scanners that are sometimes currently used for plastic films, an option for modernization with new, digital photomultipliers and powerful processing electronics is now available. Because most of the mechanical components including the web path are retained, a modernization of older laser scanners provides an attractive alternative.

Description and Classification of the Detected Defects

The classification of defects is one of the most disputed topics regarding web inspection systems. With all classification methods, the initial step is to reduce the image information about a potential defect (Patch) to a relatively small feature vector that describes the appearance of the defect with numerical values. Efficient, complete and understandable features are, after a superior image quality, the most important step towards accurate defect classification.

A commonly used feature is, for example, the "slimness", a number that increases the more the defect outline deviates from a circular shape. Of the several hundred features possible for the use in classification rules, there are typically as few as 7-8 significant features sufficient to achieve useful and predictable classification by the inspection system (*Figure 9*).

Numerous methods of image processing are available with more or less usage for efficient and predictable classification of defects; in particular at very high machine speeds.

Successful are classification algorithms that are based on expert rules (sometimes combined with a confidence weighting factor). Most recently there are automatic training methods available to create classification rules by the use of sample defects. Applying expert rules the fine-tuning of the rules and the usage of binary information is easily done.

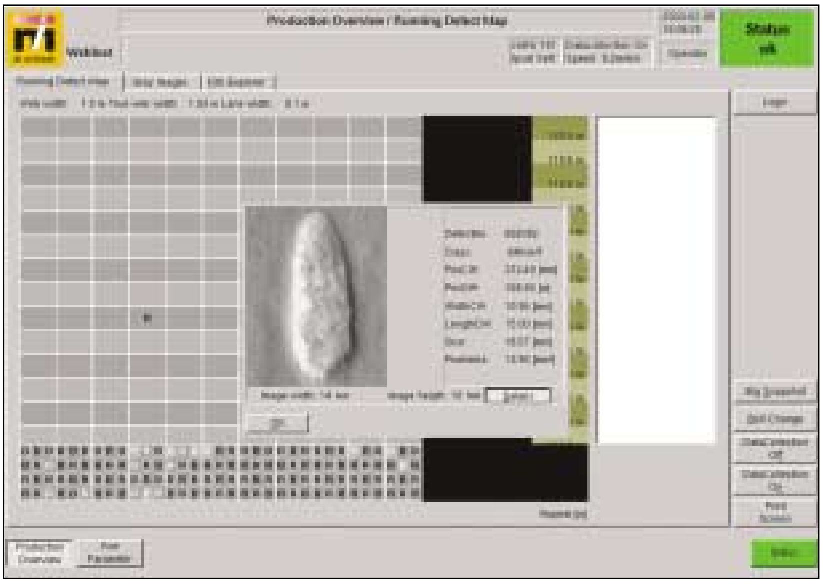

Figure 9: "Rolling" Real-Time Defect Map with Defect Details on Demand

Currently, efficient programming and a system architecture, which is specially designed for these tasks, delivers systems that can process very high defect rates without overloading. In the past, the required electronic architectures could only be done using hard-wired gate-logic. Today, programmable logic such as FPGA (Field Programmable Gate Arrays), combined with modern signal processors as well as flexible and fast memory, provides a platform that can be adapted to the specific needs of the application. The system can be scaled to virtually unlimited processing power in increments of 50 million pixels per second. Systems with processing capability of more than 1 Billion pixels per second real-time processing have, in fact, already been built by Dr. Schenk.

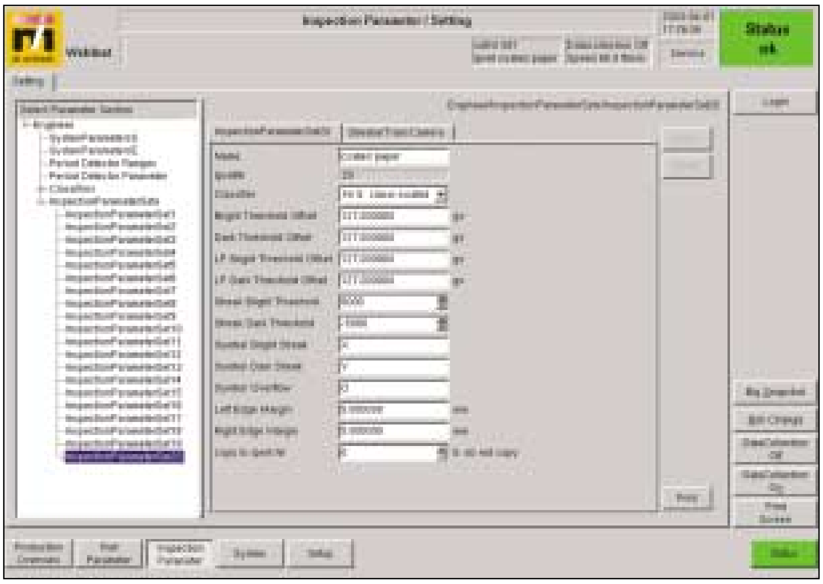

Figure 10: Recipe Selection

Simple Product Change

Often neglected but immensely important for acceptance of the inspection system is an efficient user interface, which guides the attention of the operators towards the most important production issues and allows for rapid change of product. The latter is achieved using pre-configured recipes that contain not only the quality definition (‘What is a defect and what is not?’ or ‘How many defects per a specific area are permitted?’) but also parameters that prepare the inspection system itself for the inspection of a new product (*Figure 10*). It is, for example, easy to switch between films with almost 100% transmission to films with just a few percent transmission with the same inspection system.

User-Interface

The user interface of the Dr. Schenk *WebFeat* systems use the same modern techniques and ergonomic guidelines as are used in the aviation and the semiconductor industries. Besides having no more than a 2-click menu navigation of the software for fast reaction to process situations, the system uses colors to visually indicate and emphasize abnormal process situations. As long as good material is being produced, the control panel remains monotonously grey. When a colored indicator appears, this can be easily identified by service personnel even from different angles and from some distance on the production floor. This method of using color contrasts on control surfaces has remained mostly unconsidered until now. Unfortunately, most control screen software offered today has been designed by programmers that want to demonstrate their ability of using the entire pallet of 16 million colors, and thus the screen layouts often distract from the essential information.

Streak Detector

Streaks in machine direction are a special class of defects present in almost all web production processes. They are frequently present because of the very nature of web production. The strictly down-web orientation can reduce its detectability with conventional but cost-effective diffuse illumination. Signal processors use intelligent algorithms equivalent to a down-web integration of the image to detect streaks even if their contrast is lower than the general material-related noise. The image below demonstrates the level of streak contrast enhancement possible with such algorithms (Figure 11).

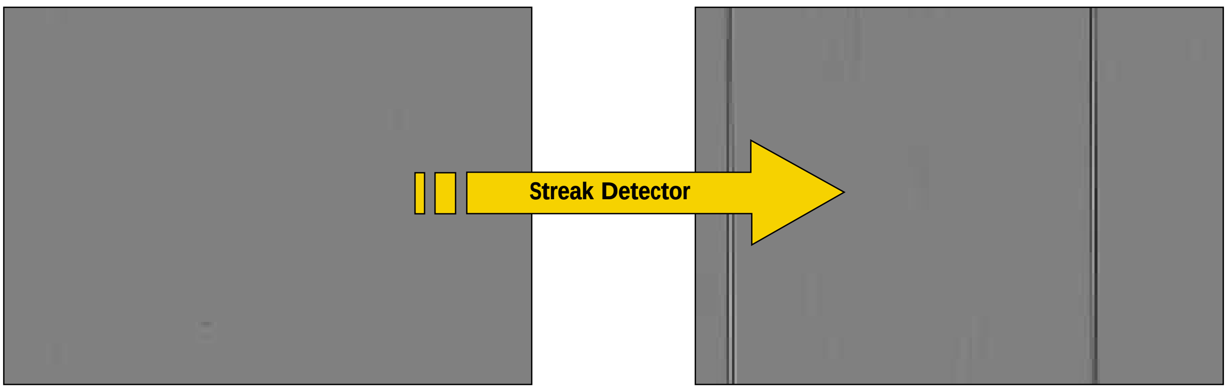

Figure 11: Contrast Enhancement with Streak Detector

Repeating Defects

Also characteristic for web production are defects that re-appear with a fixed period in machine direction. Repeating defects usually appear if a roller is damaged or if a piece of debris clings to the roller surface. The defect on the material will repeat itself with a distance given by the roller circumference. *WebFeat* provides a repeat defect detection option that searches for all the machine-specific repeat frequencies. With this feature, the respective roller and its defect is reported to pinpoint the roller (or roller group of identical diameter) concerned whereby eliminating the production problem substantially faster.

Further Usage of the Inspection Data

There is naturally the question of what to do with and how to use the defect information data that results from an inspection system. There are extensive possibilities for use of the data collected to manage the product. A summary for each roll can be printed in the form of a roll report that consists of the roll name, total produced length and a defect histogram. More extensive data of each roll can be exported into files that contain the coordinates and properties for each defect, as well as a link to the image of the defect (*Figure 12*).

These features greatly assist the manufacturer in archiving product quality, as well as separating defects created in subsequent treatment steps or by the customer from those already on the roll.

Besides defect list and representations as defect maps, the histograms both, in transverse and machine direction, are of substantial value for process control. The simple profile-representations (*Figure 13*) allow for rapid identification of specific process problems.

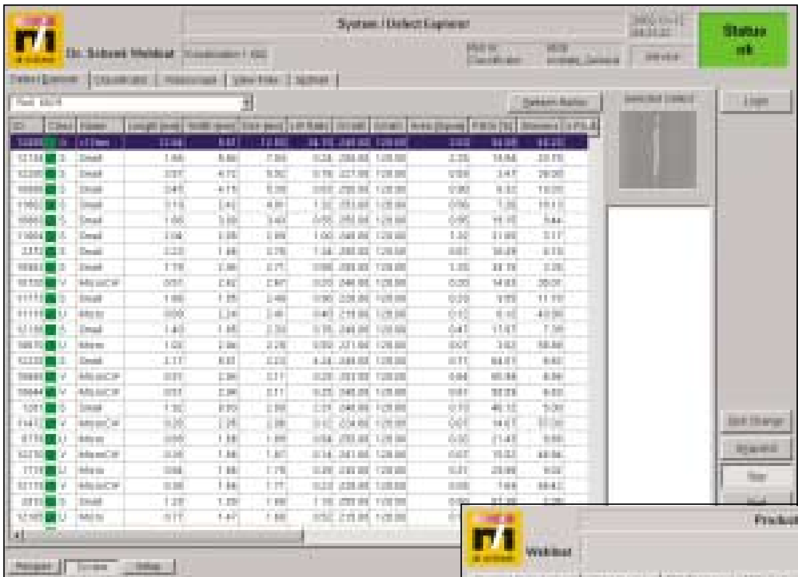

Figure 12: List of all Classified Defects on a Roll

Figure 13: Defect-Histograms as Transverse- and MD-Profile

Return of Investment

The goal of purchasing an inspection system is not to own a technically impressive system but to produce product more efficiently and more economically. How fast and how much return an investment in an inspection system will yield is certainly very dependent on the actual product inspected. The following will show a typical example.

Let us assume a production of high quality plastic film where one roll is produced in 20 minutes and sells for EUR 1,000. The primary reason for rejected (and therefore not sellable) rolls shall be die-lines, which can only be manually detected when analyzing product samples taken at the end of a roll. This process issue accounts for 5% of the production to be lost.

If an inspection system detects these die-lines on-line they are in average detected 1/2 roll earlier then with the manual sample test, because the system reports the beginning of a die-line immediately instead of at the end of each roll. The time it takes to manually take and evaluate the sample is not considered in this calculation. The in-line inspection will therefore reduce the production loss by half, because corrective action is initiated on average 1/2 roll earlier; 2.5% of the production is saved without even changing anything in the process. For the example above, the total savings amounts to approximately EUR 675,000 (EUR 1,000/roll x 3 rolls/hour x 24 hours/day x 365 days x 2.5%). The amount saved is in general higher than the typical investment for an inspection system where approximately 50% of the investment is budgeted for the inspection system itself and 50% for web-path modifications, installation and training. Multiple projects have shown that the return on investment is often even much higher then this and the projects are amortized very rapidly.

WebFeatures:

- Consistent surface inspection, covering 100% of the material surface
- Objective defect detection on ISO 9000 basis
- Immediate detection and reporting of production problems
- Long term defect statistics for production process improvement

Conclusion

Web inspection systems have evolved to play an important role in any web-based production. Carefully integrated into both, the quality and the process control mechanisms, they provide modern and high performance productions with data on defect occurrence, distribution and density that permits effective process improvement decisions. With an increasing performance to investment ratio, web inspection systems are no longer an investment that is only done if absolutely necessary, but an investment that delivers a good return.

Dr. Schenk GmbH, established in 1985, is an innovative high tech firm based in Munich, Germany.

For the second decade now, the range of products and services offered by Dr. Schenk includes comprehensive solutions for automated quality assurance and production process monitoring – areas where we continue to set new standards for the inspection of surfaces and the measurement of optical and mechanical properties, through the continuous utilization of the latest technical advances in optics and electronics.

The focus of all our activities is the perfect synergy between practical ideas and innovative solutions.

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