

Perfect Eyes

sheet must now do far more than just identify defects. It is important to provide a consistent overall concept, which besides flexible, high-precision defect detection also permits extensive quality assurance, continuous quality verification and optimization of the manufacturing process. Highly advanced systems offer the possibility of implementing a coherent supply chain from sheet production through to print inspection.

RUDOLPH KRAMPE

Requirements are constantly increasing in all sectors of the sheet and film industry due to rising raw-material costs as well as high energy and personnel costs – and all while at the same time pressure from suppliers in the Far East is increasing. Pitted against this, there are the customers' demands for defect-free film and sheet; this is acquiring additional significance due to a growing market for top-quality film and sheet that place the highest demands on production. A high-performance web inspection system will help manufacturers save on costs and raw materials, increase production efficiency and prevent customer complaints.

The requirements for web inspection are every bit as multifaceted as the production processes and application possibilities for sheet and film. These might not only differ from sheet/film producer to sheet/film producer, but also between locations or within the company group itself. It is often the case that sheet or film of varying levels of quality is produced all at the same location, and these make differing demands on surface inspection:

- **Top-quality cast film with special optical characteristics:** Zero-defect production is required for web speeds of up to 10 m/min and web widths of up to 1,800 mm.
- **Blown film for food packaging, etc.:** Priority is given to statistical evaluations, with criteria such as number of defects per roll or square meter; this data must be available for various defect types and sizes. Inspection is carried out on the film at speeds of up to 120 m/min and web widths of up to 2,500 mm.
- **BOPP stretch film:** Web speeds of over 400 m/min and web widths of more than 6,000 mm contribute to more frequent occurrences of defects. With this application, the focus falls first and foremost on registering the “catastrophic defects” and evaluating them according to statistical criteria.

Whether cast film, blown film or stretch film systems – even if these systems are very different technologically speaking – many sheet and film manufacturers still see definite advantages in using a uniform technology and operating philosophy when it

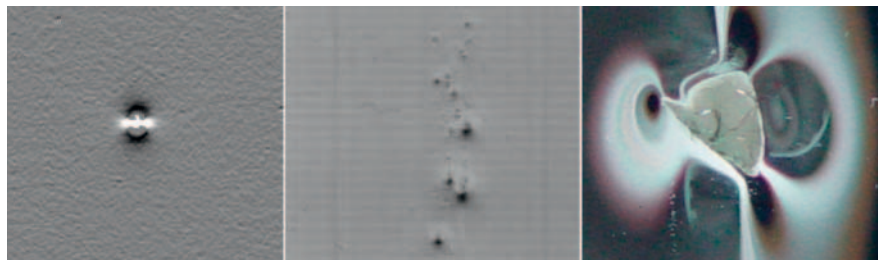


Fig. 1 Typical defects: gel, lines, black spots, inclusions, scratches, holes, optical distortion and insects

comes to web inspection. A consistent look and feel minimizes the training expenditures and saves time and money by enabling problem-free processes. For example, when the operating personnel are needed at another system, and a backup shift is on hand, then they can work with the system immediately without an induction period.

High System Requirements

The expectations for film and sheet quality are considerable, as are the demands on the inspection technology employed. Optical inspection systems are required to secure a high level of reproducible, documentable quality, and furthermore assist in optimizing the production process. For sheet and film inspection, there are currently three fundamentally differing concepts available which can be clearly distinguished in terms of certain aspects of their performance, availability and ability to communicate:

- Intelligent cameras with an integrated computer,
- Hybrid systems or embedded PC systems with the computer located close to the process,
- Surface inspection systems with the computer located far from the process.

Using an “intelligent line scan camera”, data analysis and evaluation take place in the camera itself. The computing power of this technology is limited and is rarely enough for high-quality classification. When using this technology, problems can occur – when there are large-area defects, for example – if the two cameras detect two defects instead of one because of the absence of information exchange in the overlap area. This combination of camera and computer furthermore requires a lot of installation space, which can complicate integration into the production system. Another drawback stems from possible problems resulting

Translated from *Kunststoffe* 10/2007, pp. 240–244

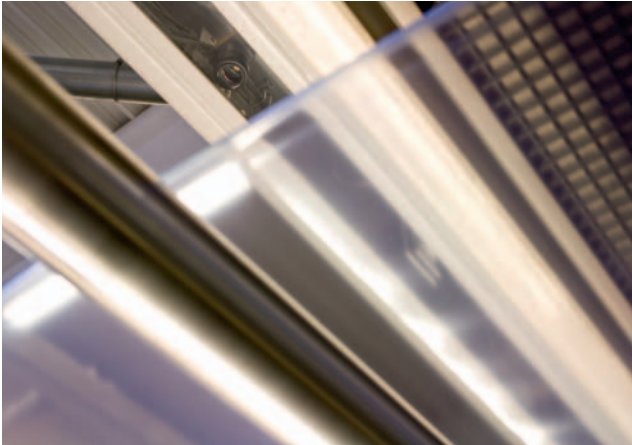


Fig. 2 Highly developed surface inspection of cast film, blown film and stretch film up to polarized film for TFT displays and monitors

from the process heat, because the camera and computer are located directly above the production system.

The latter can also lead to difficulties in the case of hybrid and embedded PC systems. With these systems, the computer is located directly next to the camera. Since the PC is installed over the web near the process, vibrations and exposure to heat from the production process mean there is a greater danger especially for moving parts, and particularly for the computer's hard drive. If the computer should fail, then a protracted production stop can result due to the often-difficult accessibility.

World-wide, the most prevalent concept in surface inspection systems is the type in which the camera delivers the data to a computer located in a control cabinet. The major advantage of these systems, which also includes the Smash surface inspection system (manufacturer: Isra Vision AG), is their high flexibility and performance, which particularly comes to bear at high web speeds when many defects occur. Because this technology does not place any moving parts in the way of the production line, the susceptibility to failure is minor. All components for data processing and preparation (data mining, classification, data backup) are housed in a sturdy control cabinet protected against dust, heat and vibration. If needed, this cabinet can be air-conditioned. Network connection and remote diagnosis are standard. All this guarantees a high level of operational reliability, and is practically maintenance-free. Because it is placed on the floor, the control cabinet is easily accessible. If it should become necessary to change out a computer, then this can be carried out per plug & play, which will keep the downtime to a minimum.

A High-Performance All-in-One System

This modular, highly flexible system consists of high-resolution CCD cameras with 512 to 12,000 pixels for black and white and color photographs, custom illumination technology for the various applications and industrial computer systems. The high-speed cameras operate at up to 360 MHz. With line refresh rates of 96 kHz, the cameras are faster than all competing products to be found on the market. The high sampling rate brings about a very high pixel resolution, thus creating the high-definition defect images that are necessary for further classification and process analysis. Smash even recognizes the tiniest defects of 100 µm or less. Because of its modularity, the system can be implemented in just a few days, and its scalability allows it to be expanded without difficulty.

The demands on an inspection system are very high. Years ago, knowing the number of defects in a roll and their differentiation into light and dark defects, along with the defect size, were enough for the film and sheet manufacturers to obtain indicators about the causes of the defect. Today, they demand precise defect detection, which requires crystal clear images, along with a classification system which describes the defects exactly.

Smash does not only inspect for the typical defects such as gel, fisheye, scratches, burn marks, condensation drops, insects, die defects, double-layered film, angle or polishing defects (Fig. 1). It also recognizes optical defects which can result from irregular distribution of the plastics melt. The defect types and sizes to be recognized can vary greatly. The same applies to important optical material properties such as gloss or opacity resulting from problems with the raw materials or coating. Smash can satisfy at even the highest level, the inspection of polarized films for TFT displays and monitors (Fig. 2). These films place by far the highest demands on detection, because the defect-free nature of the material has a major influence on the function and the overall appearance of the end product.

Optimizing Production Processes

Automatic surface inspection systems must, however, offer substantially more than just defect recognition, since precise defect recognition should go without saying nowadays. In order to step up productivity and increase quality, exact defect classification for cause analysis and trend data for process optimization are simply indispensable.

What overall benefit does the manufacturer gain? For example, trend figures show when a line needs to be cleaned, rather than subjecting it to periodic cleaning that may come too early. Repeat defects allow conclusions to be drawn about the state of the rolls; detailed offline analyses help if there are complaints. And exact classification of defects such as die defects allow for rapid, targeted corrective measures to be taken.

The Smash inspection system is complemented by "data mining", an important tool for improving internal process efficiency and quality. The tool collects the production and defect data and makes it possible to transfer them to a database of the user's choosing. Statistical data from multiple machines in various locations can thus be combined – across factories and even, if desired, across the world. A quality manager can thus, for example, evaluate which of the production lines in his company group is currently producing the best material, so that he can then assign the order from the customer with the highest quality requirements to that line.

It is crucial that the system meet the needs of a wide range of users. Access to information is important to everyone: whether plant or production manager, head of a manufacturing division, shift manager or quality control officer, all require specific information.

Users can employ the data provided to carry out analyses by date or time, batch, type of defect, product type or shift, thus generating valuable feedback for production optimization. Comparative reports about trends or summaries of information are generated automatically – predefined report types are sent by e-mail according to a predetermined workflow. The benefit for users is rapid, quantified, precise reports that are tailored to the individual user:

- The plant manager gets details of the tonnage produced and a defect report at the end of the week.

- The quality control officer is regularly informed of all quality-relevant parameters.
- The shift manager is informed of the results for the shift before clocking out, or is alerted if the number of defects exceeds a specified level.
- The head of production will want to know at the start of his working day how the previous day went.
- The director of a manufacturing division is interested in the status of all production lines world-wide.

Efficient Defect Classification

With the complementary module Quickteach, the detected defects can be simply and intelligently determined and classified. Many different attributes are incorporated when performing classification; the classifier does not, however, take size into account. Defect size is an additional, independent decision criterion. Material defects are described unambiguously and assigned specifically, with a high degree of precision. Users can define the number of defect classes according to their requirements and the wishes of the customer, and have complete freedom of choice when defining, assigning and designating defects.

Quickteach is an intelligent classifier – in other words, there is no need to interrupt inspection during the teaching procedure. Images are automatically collected during production. If a defect is detected, the software compares the defect features with the “taught” classes and defines the defect based on the class to which it belongs. The particular advantage of the classifier is its extremely short start-up period. The system’s rapid learning curve

saves the manufacturer of sheet or film time and money, as consistent results are available immediately following installation.

Surface defects are automatically classified and saved, along with their features, on the hard drive or a CD, or made available on the company network. Users also have the option of defining different alert signals for each of the defect types. Moreover, users are informed of defects, including the relevant defect images, in real time during the very process itself. Furthermore users can employ a marking system to mark the defects on the sheet or film in readiness for further processing.

Adding Value throughout the Process

In order to add the greatest feasible value, it should also be possible to install the inspection system on a winder after slitting the sheet or film lengthwise, and even right up to the printing and coating phase. Smash does not only enable sheet or film to be inspected during its production and for target levels to be secured through first-class quality and a low reject rate. It can also be used to generate profit and benefits for the company in the later stages of adding value. Isra Vision offers the sheet and film industry highly-developed sheet and film inspection and print inspection all from a single source, connecting the two areas through its data mining component. ■

THE AUTHOR

DR.-ING. RUDOLF KRAMPE, born in 1956, is an executive at Isra Surface Vision GmbH, Herten, Germany.
Contact: info.surface@isravision.com