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OCS Optical Control Systems GmbH, Witten/Germany

Big Brother for Films

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Surface Inspection. There is a general trend in on-line analysis of plastic films for self-learning, "intelligent" systems as part of higher-level quality information or production data acquisition systems. With these systems, film producers can monitor the quality of their products continuously and objectively and therefore optimise the production process itself.

OLIVER HISSMANN

Is it a fly, a gel or a tiny hole in the film? Modern surface inspection systems will immediately detect and identify surface defects in plastic film. High-performance cameras, fast data transmission and adaptive software allow comprehensive and objective on-line monitoring of plastic film and help troubleshooting. Producers benefit with a reduction in machine downtimes, raw material savings, optimised compounding and improved customer loyalty due to guaranteed quality.

Of Scan Rates and Scan Line Lengths

The concept of embedded PCs allows modern inspection systems to deliver a data rate of up to 80 MHz per camera. All material data, including frame analysis data, i. e. complete images and not just individual lines, can be transmitted to the server and stored there. Image analysis is carried out under real-time conditions. Alarm functions can be set. A so-called live image with flaw marking – a real-time monochrome image of the running web without line compression – allows colour marking of flaws and the integration of information on their size. CCD line scan cameras with 2048, 4096, 6144 or 8192 pixels can be selected to suit the application. They deliver scan rates (picture recording speeds) of between 10 000/s at 8192 pixels and 40 000/s at 2048 pixels. Thus, high resolutions can be delivered in the direction of the web even at high speeds.

Due to advanced special lenses and the technological progress in the development of CCD sensors, longer CCD lines (e. g. with 8192 pixels) can today be displayed with a sensitive display quality similar to that of shorter CCD lines (e. g. 2048 pixels). Since the price differences between different CCD line scan cameras are immaterial, film producers choosing long line CCD sensors can save significant investment costs without detriment to the inspection quality, as shown in the following example: a plastic film web with a width of 1600 mm running at a maximum web speed of 120 m/min is to be inspected with a resolution of 200 µm in web direction as well as in transverse direction. The achievement of this resolution requires the introduction of either four CCD line scan cameras with 2048 pixels each, two cameras with 4096 pixels each or a camera with a resolution of 8192 pixels. Hence, the 8192-pixel camera has the best price/performance ratio since one single camera offers the lowest capital investment, maintenance and handling costs.

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Self-learning Systems

Technically advanced inspection systems offer a so-called "easy-teach-in" feature: the operator singles out surface defects with the help of images and classifies them according to categories. The classifier automatically determines the inspection parameters for the individual defects. Since they operate with Fuzzy algorithms, these systems can distinguish between defects such as flies and black specs and mark them accordingly (Fig. 1). This distinction is of crucial importance, especially in the area of food packaging, because it allows the detection of the source, i. e., whether the defects are caused within the clean room or as part of the production process. Particles such as fluff, which may have been attracted by static, can also be classified properly and are not mistaken for defects by the inspection systems.

Practical Application

Film extrusion has to contend with the occurrence of several classic flaws such as streaks, flow marks, gels, black specs with gel ring and chatter marks. When detected, these defects must be classified. Moreover, the exact position of the flaw on one particular roll and one particular lane must be determined.

A 3-D-flaw analysis provides film producers with a three-dimensional display of the flaws, which allows a deduction of the cause. Thus, film producers can develop a better feel for the surface structure of their product.

Statistical representation is of critical importance in the area of blown film production, since they allow the prevention of defects, for example the detection of production trends in the area of barrier film production (Fig. 2) to introduce measures such as purging on time. Due to the rotation of the collapsing boards, a statistic record of gels is usually sufficient for blown film applications.

The production of laminating film or film for liquid packaging however, requires a complete inspection of the entire film width, so as to pinpoint gels, black specs, insects or holes starting from a diameter of 200 µm inside the film bubble. These flaws can be removed at a later stage.

In most cases, full inspection of the film web is prerequisite for cast or stretch films used in hygiene, medical or food packaging applications, which are designated for post-production labelling, so as to allow immediate interference with the produc-

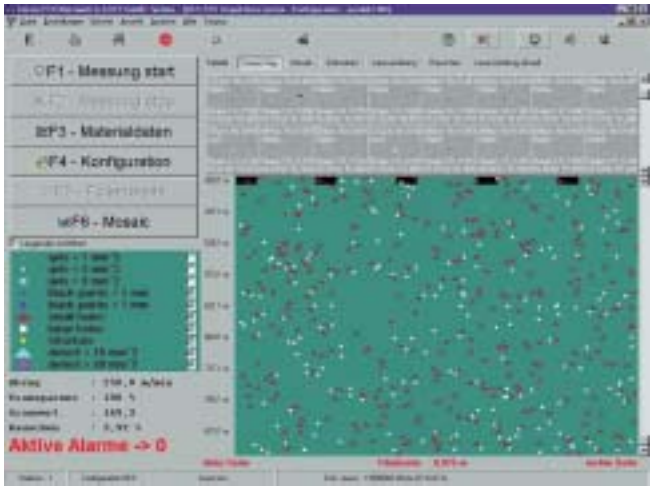

Fig. 1. Self-learning systems are able to distinguish between different surface defects which are then displayed on a symbolic "defect carpet" of the running film web

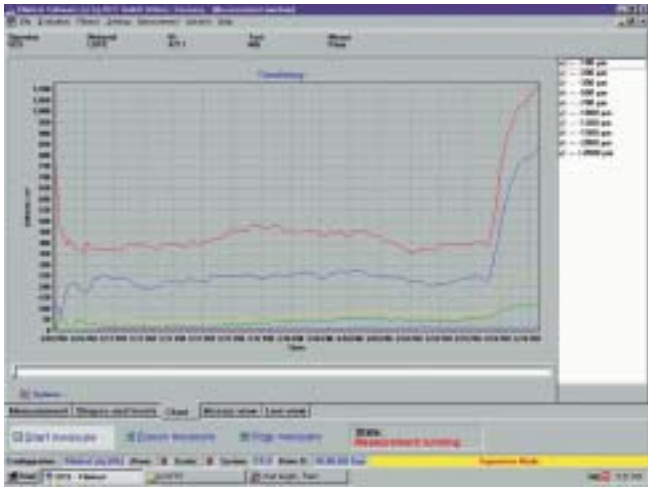

Fig. 2. Statistical representation of the defect rate, e.g. gel content, help to recognise production trends at an early stage

tion process if necessary. As in blown film extrusion, the detection of the film web's gel content also allows optimisation of independent extruder parameters such as the temperature or others. While it is economically viable to monitor stretch film lines with full film inspection systems along the relatively narrow extrusion process (from 1000 mm to 1400 mm), partial inspection (e. g. with an inspection width of 1000 mm) of the relatively wide stretching process (from 4 to 10 m) is usually sufficient. Thus, the line operator can provide a quick analysis of the source of surface defects, e. g. either the extrusion or the stretching process and interfere with the process immediately. Some cases however, still require full monitoring along the entire stretch film web, particularly if holes, gels, black specs, contaminations or insects play a critical role (Figs. 3 and 4). Extremely high haul-off speeds with up to 600 m/min in cast film or stretch film production and the desired resolutions of below 200 µm render top-of-the-range line scan cameras with a data transmission rate of 80 MHz imperative.

In flat film production for thermoforming applications, particularly for food packaging, a 100 % inspection is prerequisite for smooth processing (thermoforming, labelling). The acquisition of a combination inspection system suitable for both transparent and opaque films with different pigmentation is the most economically viable solution. Bilateral inspection of opaque film with total reflection in addition to a camera range for transmitted light inspection of transparent materials requires three times more line scan cameras than a suitable combination system.

Products with significant fluctuations of the material thickness, particularly incident light applications, require the introduction of a special lens with auto focus. The focus is automatically adjusted by a software. This software tool is part of the inspection software. Characteristic applications for this device can be found in the extrusion of sheet with a material thickness range of 2 to 12 mm, where full monitoring of the individual sheet is of crucial importance, because optimisation of the edge trimming can lead to significant raw material savings: sheet which exceed the tolerance levels are cut at a length of 800 mm, sheet within the tolerance levels are left at their normal length of 3000 mm. Moreover, every sheet can be provided with a quality protocol, while all information on the sheet quality is stored on a central server and can be accessed at a later date.

These inspection systems are also of benefit for the production of other homogeneous continuous materials such as silicone-coated paper, coated materials, non-wovens or adhesives. For these applications, defects such as contaminations, scratches, condensation, insects or lack of adhesives are of crucial importance. Extremely high production speeds and desired resolutions of below 200 µm render top-of–the-range line scan cameras with a data transmission rate of 80 MHz imperative.

As a side effect, surface inspection also allows the determination of the absolute and relative transparency for transparent or translucent materials. Deviations from the desired transparency levels can be remedied by direct changes to the production process parameters such as changes to the roll temperature, which curbs the production of rejects.

Fig. 3. Display of surface defects in one film web

Lighting Technology

The application of the right light is prerequisite to precise surface inspection. Fluorescent light with a high switching speed, glass-fibre lights, IR or UV lights are used for different applications.

Both incident light and transmitted light sources are suitable, depending on the application. Thus, physically uneven opaque surfaces, such as

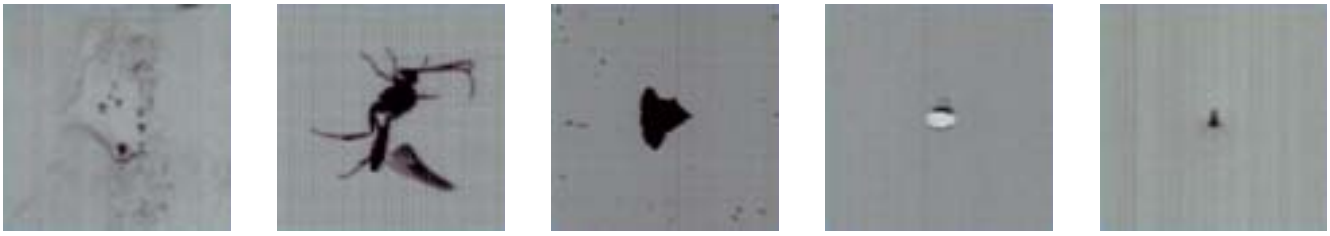

Fig. 4. Different types of surface defects: recess, insect, contaminant, hole, gel

scratches on the coating or on silicone-coated paper can be safely detected. Diffuse incident light is used to detect defects on smooth surfaces such as contaminations on the coating or on the silicone-coated paper.

Integration of other Measuring Methods

A combination of surface inspection systems and other measuring methods is possible. Haze band measuring systems operating according to US ASTM standards, which are based on the Ulbricht globe photometer, are suitable for on-line integration into the inspection system. Haze bands provide information on the contrast when looking through film.

This can be combined with an on-line gloss measuring system, which operates in accordance with ASTM, ISO or DIN standards. Low gloss is measured at 85°, while medium gloss is measured at 60°, high gloss is measured at 20° and the angle of incidence is measured with gloss categories ranging from 0 to 100. The measuring data of all three systems can be recorded and displayed on a central monitor. Critical deviations can trigger set alarms.

Open interfaces (Ethernet, Profibus, Modbus, RS 232 etc.) allow the integration of a higher-level quality information or production data acquisition system. More than twenty inspection systems operated at different production sites all over the world were integrated into an SAP system. Thus, the quality of film webs at different production locations can be analysed objectively all over the world. This global production monitoring system which allows the introduction of an objective standard quality generates cost reductions and provides producers with a leading edge in this global cut-throat market. ■

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