Plastic films are produced for a wide range of applications: for packaging of food, functional films for LCD-displays, films for organic solar modules and OLEDs and many more. Focussing on the production process, starting with the base material and followed by converting steps, we can find out that due to the high requirements on the film materials as well as complex layer configurations a precise control of the production process is essential in order to optimize the production costs.

Before considering the integration of an Automatic Optical Inspection system (AOI) into a production line, one main question comes up: Why is it necessary to spend money for this investment, as manual quality control by human inspectors seems to be sufficient? A few simple calculations can show that manual inspection covers only a minor part of the web material, a tremendous high number of defects are not detected in this way and defective material is delivered to the customer. Going through this chain of facts it is finally quite easy to find good arguments for investing in an AOI.

Fig. 1: Manual inspection, covering only a minor part of the web

AOI systems fulfilling this job are mainly based on three components:
- digital line cameras (CCD or CMOS technology)
- LED line illumination (several wavelengths possible)
- evaluation electronics, comprising dedicated hard- and software

Their key applications are:
- Quality Control for the detection of local product irregularities to ensure that defective material is not processed any further nor delivered to the customer.
• Inline monitoring of material properties over the full width and length of the material, such as thickness, gloss, opacity or surface topology.
• Process Control for the optimization of the production process; here the challenge is the implementation of a fast feedback on production parameters in order to react immediately (and even automatically) upon process deviations detected by the AOI.

Fig. 2: Inspection system, application throughout the production process

**Demonstration of Results**

The presentation will demonstrate these methods and capabilities by results of defect detection and evaluation in/on various film materials, e.g. base and converted films.

**Gels/fisheyes**

**Wrinkles**

**Bubble/inclusion**

**Coating voids**

Fig. 3: Examples for local imperfections in plastic films and coatings
State-of-the-Art and Innovation

AOI systems are already applied in many production sites. As state-of-the-art CCD line cameras (or recently also cameras based on CMOS technology) with increasing pixel resolution are combined with liner illuminations. So far so good - but what is new, what are new capabilities which push to save money and time in plastic film production?

Main new features of the latest AOI systems are described here:

- Light sources are making an intensive progress. They are built up with rows of LEDs, which are now available in several wavelengths. This offers the possibility to inspect with light in varying colors, which selectively increases the sensitivity of the inspection system for certain defects or material properties.

- In order enhance the performance of the defect detection and evaluation the AOI system can analyse the same defect by multiple images in one scan (Multiple Image Defect Analysis – MIDA; see Fig. 4). MIDA for example allows looking for defects with a bunch light sources (e.g. with different colors or different angles of incidence) in parallel. This helps to optimize the yield of a film production line, independent from the production process type (extrusion, cast, stretching, …).

- In parallel modern AOI systems can monitor the homogeneity of film and coating properties and return their absolute measurement values for the full material width in-line (Fig. 5), while standard optical process control systems monitor coating properties by measuring only a few spots on the material, mostly with a significant time delay after the production of the material (Fig. 6).

- Additionally enhanced quality analysis methods are described based on the evaluation of grey value distribution over the whole sample (e.g. by histograms, giving the spatial frequency of grey values within certain sub-areas of the material; see Fig. 7). This new approach allows more sophisticated detection of defective areas in or on a plastic film, even in case the surface is structured / textured.

- The latest development is focussing on even ‘hidden’ web surface properties (such as the intensity of the corona treatment; see Fig. 8); they now can be monitored inline, which gives an important input for the further processing of plastic film materials. This capability of the AOI system is pretty new and was developed only a few months ago.

Absorption image (reflection)  Absorption image (transmission)  Distortion image (transmission)  Scattering image (transmission)

Fig. 4: Multiple Image Defect Analysis (MIDA) of the same defect (inclusion in plastic film)
Fig. 5: Monitoring of the thickness of the adhesive coating on an adhesive tape

Fig. 6: Automatic process control of a production process by AOI data
Fig. 7: Histogram of grey values for evaluation of defective areas

without corona treatment

with corona treatment

Grayvalue Histograms

Fig. 8: Corona treatment monitoring
Fig. 9: Benefits of an Automatic Optical Inspection System, installed in a production line

- **Increase of yield**: Automatic process control via parameter adaption in live production
- **Cost reduction in finishing**: Quality evaluation prior to costly subsequent production steps
- **Consistent performance**: Long-term operation without any decline of the performance
- **ROI < 2 Years**: Depending on a variety of production process factors