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Standard Search for Specks

Film Inspection
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Film Inspection. Applications markets expect 100 % quality control on the one hand while producers of films would like to avoid scrap and optimize the production process on the other. One problem is the huge uncertainty over the necessary degree of resolution in error detection.

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Film inspection systems are increasingly becoming an essential part of production lines. They monitor the film web in transmitted light (in the case of transparent and translucent films) or reflected light (opaque films). A combination of both illumination arrangements is possible when not only transparent but also opaque films are made or processed on the same installation.

Modern systems detect surface defects such as specks, gels, black specks, fish eyes, coating tears, streaks, flow lines, and insects (Title picture, Fig. 1). The operator can program the types of defect into the system which will then automatically determine the corresponding criteria for classifying them.

However, the user needs to specify the defect size and the frequency threshold which triggers an alarm. This should logically be done in consultation with the end customer.

Definition: Specks and their Causes

Specks are small film inhomogeneities that are characterized by their area (size in transmitted light) and their elevation above the film surface.

However, defects, such as specks, are not defined in any ISO or DIN standard, nor are there any clear rules on what constitutes scrap, etc. The once widely used statement “my film has no specks” is now outdated. Specks occur in all films and are an unavoidable outcome of the production process and the properties of the polymer. Specks, as it were, are only a matter of resolution.

Film manufacturers know from experience that the reasons for such defects can be broken down as follows:
- Extrusion line (non-optimal screw geometry, deposits, etc.) 20 %,
- raw material (impurity, cross-links, etc.) 25 %,
- production process (wrong temperature parameters, non-optimal purging, etc.) 15 %,
- pellet transport, external and internal (contamination of silo trucks, PE abrasion, etc.) 40 %.

Gel Count Standards at Raw Materials Producers

Raw materials manufacturers have been using gel counts for decades to perform unified internal quality control (Fig. 2). These entail automatically extracting 50 samples every hour and transferring them to an extruder fitted with a gel counter in a cleanroom for analysis. The data are sent directly to the process control system, which uses the data to regulate the process.

Resolutions for online checks are in the range of 50 µm for standard applications such as PE or PP production. Special applications such as polymers for high-voltage cable work with resolutions down to 5 µm.

Cataloguing Defects

Defects each have their own causes and they also give rise to various problems in further processing. However, as already mentioned, there is no single standard for systematically classifying defects. Descriptions of them can therefore vary substantially.

That is why it is important to aggressively tackle this issue and to sensitize both
suppliers and customers to the issue of defect classification and the resolution or size detection (see application examples). Typical types of defects found in extrusion are:

- Speck/gel (unmelted material or cross-links – like a water drop in a transparent film),
- black specks (cracked or burnt material – brown or black),
- fish eyes (unmelted material or cross-links – often in opaque film with subsequent thin spot; but this defect is often equated with a speck).

**Product-related Requirements**

**Optical Films.** In the field of optical films, resolutions of 50 µm are the classic standard, since freedom from defects 100 µm in size and larger must be guaranteed. Nonetheless, 25-µm systems are also used in coating installations for optical applications. However, resolutions below 100 µm require the use of cleanrooms because otherwise too many pseudo defects such as dust, etc. are detected.

**Pharma Films.** Pharmaceutical films require system resolutions of around 200 µm, as defects such as holes, insects, or black specks of 0.1 mm² must be reliably detected. These are highlighted in the production process and then removed during assembly.

**Technical Films.** Technical films are very often extruded on blown film installations. Since these installations do not often produce in cleanrooms, 100-µm resolution is readily achievable and also practical. It is now standard practice to classify specks by their diameter: <250 µm, 250–400 µm and >400 µm.

**Hygiene Films.** As for hygiene films, holes and specks larger than 1 mm must be reliably detected. This requires a resolution of 500 µm.

**Food Films (PET Thermoforming Films).** No visible defects such as insects and black specks can be tolerated in thermoforming films for food. Resolutions of around 200 µm are the current standard on the market.

**Surface Protection Films.** Protruding specks are very critical, especially for surface protection films. However, since these are hard to determine, the diameter of the speck is multiplied by a factor, such as 1.1–1.5 times the film thickness. Resolutions are thus in the 100 µm range and above. The upper limit for specks in...
these applications is around 1 mm in diameter.

**Fruitful Collaboration**

Windmöller&Hölscher KG, Lengerich, Germany, and Optical Control Systems (OCS) GmbH, Witten, Germany, have been collaborating closely for years in the field of quality assurance. W&H’s extrusion pilot plant boasts several blown and cast film installations fitted out with FSP600 OCS inspection systems. Among them is a 9-layer Varex blown film line that is available for the production of polyolefin and barrier composites (Fig. 3). A mobile OCS unit also provides the necessary flexibility for fitting out other machines in W&H’s technical center with an inspection system.

In addition, OCS’ technical center has an inspection rewinder for customer trials. Also, both companies have mobile inspection systems for conducting in-line tests in production shops.

The outcome of this collaboration is that the two companies have acquired a comprehensive level of expertise in the feasibility and integration of inspection systems that customers of W&H and OCS can avail of in full. The findings are channelled into process optimization projects and designs for extrusion systems, screws, etc. (Fig. 4).

The OCS inspection systems are integrated into the W&H system control and alarms are displayed on the control panel of the extruder. Moreover, specks data are also integrated into the roll history for further analysis.

**Conclusion**

As already mentioned, in addition to the extrusion line, the production process can be a source of specks, deposits, burns, scratches and other surface markings. Various modules and components are available for eliminating these and other sources of defects as much as possible:

- Rheologically optimized modules, such as extruders, blown film dies and screw assemblies;
- modules for automated product changeover (easy change; purge assist, profile booster) aimed at speeding up setting and resetting the installation, including production of “good” material. This ensures that the dwell time of the materials in the installation is kept to a minimum, because the longer the materials remain in the machine, the greater is the risk of deposits or material burns;
- low-contact or non-contact film guiding elements, such as special guide rolls in the calibrating cage or a so-called Nostic package in the take-off, permit contactless guiding of the film in the entire line.

In addition, each practitioner should be aware that, despite an optimal extrusion die, regular maintenance and cleaning of the installation is still essential. This service includes careful cleaning of extruder sets and entire blown film dies in order to avoid the risk of speck formation due to contaminated tools. In addition, any potential damage is detected early and corrected properly.

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