Automated Color Measurement for Bulk Materials

# Inline, Online, Atline But Not Offline

With automated color measurement, it is possible to check the color of pellets during production. This saves time, increases the process reliability and quality and thus reduces scrap. This can be achieved with a specially developed color measurement system.

With the measuring system, color analysis measurements are possible inline, online and atline. This allows for quick intervention during production. © SKZ

In compounding, many of the materials used and produced are bulk materials. As intermediate products, they often determine the quality of the final product. Therefore, quality control close to the process is crucial for a high-quality product. Of course, this also applies to colored granules. Color is closely associated with emotions – for example, blue is often associated with relaxation, red with passion and green with harmony [1]. The recognition value of brands is also very often related to their color. Other than the shape, the color of plastics is the first perceived characteristic of a product. People often make the decision whether to buy a product within about 90 s. This decision is oftentimes (62 to 90 %) based on just the color [2]. Even small differences in color give the impression of poor quality, even if the technical properties are otherwise impeccable. For this reason, enormously high expectations are placed on the quality and consistency of color.

Due to these high requirements, continuous quality control is essential. Typically, this is done by laboratory analysis. For this purpose, samples are taken during production, which are then injection molded into plates. After cooling to room temperature, these are visually inspected and analyzed with a laboratory spectrometer. Thus, hours pass between sampling and measurement. This method is also state of the art in the field of color formulation, which makes it possible to adapt the desired color shade (with possible iterations for color correction) for new products or formulations as precisely as possible to the requirements and customer wishes. Batches in production are usually approved after assessment of a sample that complies with the quality parameters. However, if a significant deviation occurs, the entire batch produced within this timeframe is scrap. To keep the time delay and thus the production of scrap for a set color as low as possible, a method that allows a near-process control in a short time must be found.

## *Applicable for Inline, Online and Atline*

There are several options for in-process quality control. A distinction is made between methods that measure in the process (inline), measurements in a bypass (online) and measurements close to the production site (atline) (**Fig. 1**). With the aim of measuring as flexible and close to the process as possible, ColorLite GmbH, together with the German Plastic Center SKZ, has developed a measurement concept in a prototype as part of a publicly funded project that can be used inline, online and atline.

The system consists of a spectrophotometer with an external measuring unit connected to a sample chamber. The measuring unit is connected to the central unit via an optical fiber and electrical cables and is housed in a separate small control cabinet. Built into the control cabinet is the industrial computer with a touch screen for operation, which could also be connected to the production process control system via an industrial interface.

## *Mobile Measurement System*

The pellets are illuminated by a white light from an LED-array. The reflected light from the sample gets directed to the evaluation unit via light fibers, where it is spectrally analyzed by a grating spectrometer. Diffuse homogeneous illumination is very important when measuring strongly structured surfaces. This illumination is generated by a barium sulfate coating on the inside of the measuring head.

For inline applications, the measuring chamber can be installed above the dosing unit and thus enables controlling 100 % of the masterbatch used. The feed for the prototype is provided via a suction conveyor (type: Metro HLI 50–1-A220–0, manufacturer: Motan ColorTronic). This setup is also suitable for online applications. In this

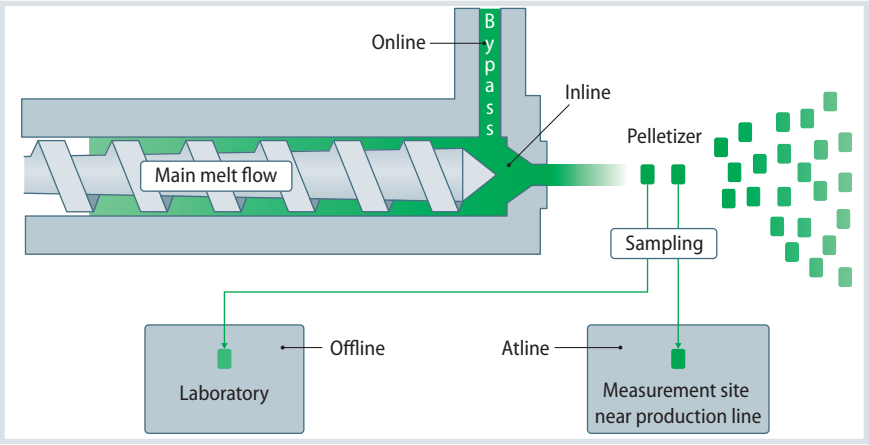


**Fig. 1.** Overview of measurement methods based on a compounding process: inline, online and atline measurements are analysis methods close to the process. Source: SKZ; graphic: © Hanser

case, both the educt and the pellet product can be sampled.

SKZ has also designed a substructure specifically to make a flexible, mobile atline application for the prototype possible (**Fig. 2**). This enables measurements to be made directly on each extrusion line without additional expense. As a result, the time delay between production and measurement is very short, which minimizes any possible scrap production.

## *Automatic Measurements in the Common Color Spaces*

The measuring chamber is equipped with a level sensor (type: KG5306, manufacturer: IFM Electronics), which automatically triggers the measurement as soon as the measuring chamber is fully filled. After the measurement, the bulk material is discharged via a hydraulic trap door. During the measurement, the reflection in the wavelength range from 400 to 700 nm is detected within a measuring spot of 120 mm diameter. This range approximately represents the visible wavelength range.

Using this method, the usual color spaces (CIE Lab, LCh, etc.) can be mapped in addition to the recorded spectral data. The recorded data also includes the temperature of the bulk materials, which is monitored via the additionally installed infrared temperature sensor (type: CS LTH, manufacturer: Optris). The ColorDaTra software, which was specially developed by ColorLite for the project, takes over the control of the sensor technology, the triggering and execution of the measurement and the output and display of the measurement data. All measurements are performed automatically with the desired settings. Only the calibration at the beginning of the measuring day is done manually. However, this requires little effort.

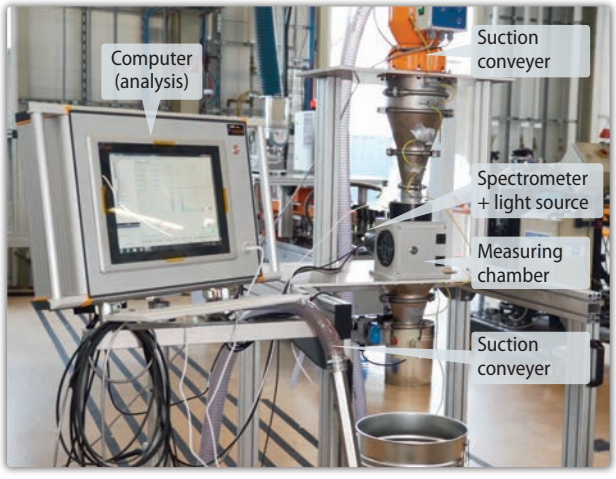


**Fig. 2.** One of the prototypes is a mobile version that can be used for atline measurement. © SKZ

If there are fluctuations in temperature, thermochromic effects occur that influence the color measurements. Thermochromism refers to the property of a substance to exhibit a reversible temperature-dependent color change [3]. The effect is due to a change in the crystal structure of the pigment. For color measurements in the laboratory, which are often carried out according to DIN 5033–4, the temperature of the sample and the laboratory must be kept constant. Often, thermochromism at elevated temperature leads to a darker and less saturated color (**Fig. 3**). Red pigments in particular are very thermochromic. At a temperature difference of 20 °C, a color difference dE of 2 is already possible (**Fig. 4**). »

## Info

### Text

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### Company Profile

ColorLite GmbH, founded in 2003 and based in Katlenburg-Lindau in Lower Saxony, Germany, specializes in spectral color measurement technology. The company offers inline solutions for a wide spectrum of applications such as film, extrudate, granulate and powder measurement. The product range also includes mobile and stationary spectrophotometers.

***www.colorlite.de***

### References & Digital Version

You can find the list of references and a PDF file of the article at

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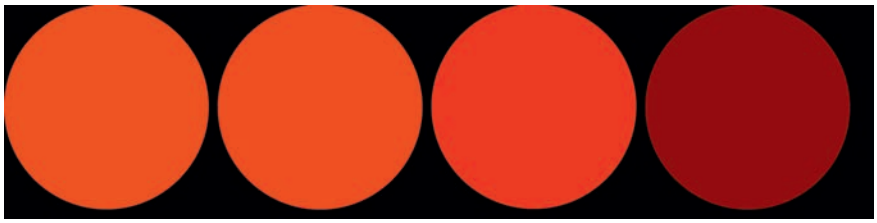

**Fig. 3.** Temperature-induced color change, known as thermochromism, is common among red pigments. © SKZ

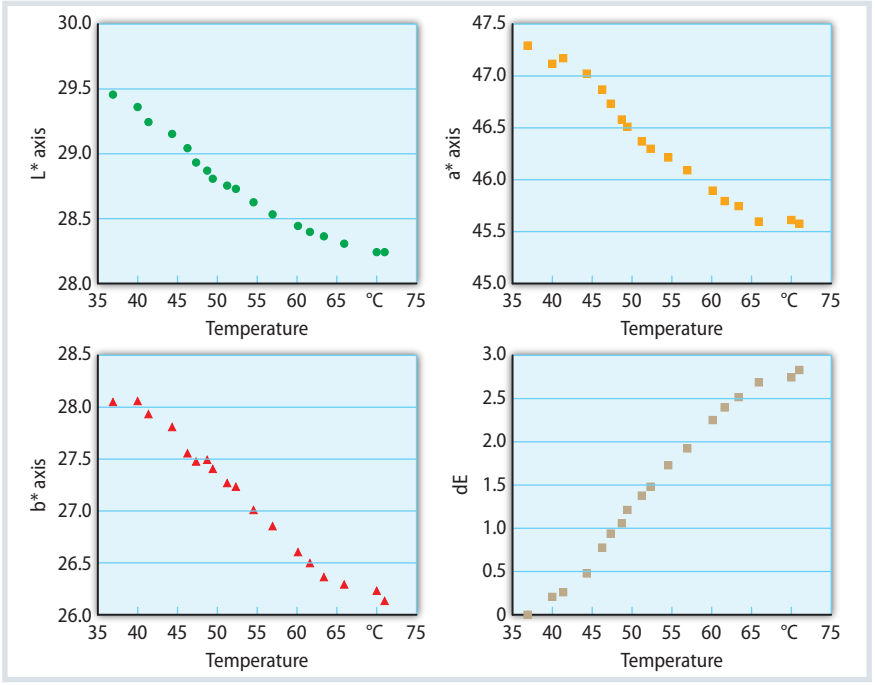


**Fig. 4.** L*, a*, b* and dE values of pellets (Maxithen Red) at different temperatures: with increasing temperature, there is a clear deviation in all values. Source: SKZ; graphic: © Hanser

## All Sights on Thermochromism

Temperature fluctuations throughout the day are not unusual in production halls. The sample temperature can also vary considerably. For example, a freshly produced pellet can still be at a temperature of 70 °C, depending on the granulation and the type of cut-off. Thus, monitoring the temperature is essential in order to correct thermochromic effects if necessary. Since each pigment shows thermochromism differently, calibration series are necessary for such corrections [4].

## Granules Can Be Analyzed without Large Deviations

Granules differ greatly from injection-molded plates. So-called white fracture can occur during cold cut. In this case, the edges of the granules appear white. In addition, the bulkiness of the granules plays a role in the measurement. Thanks to the large measuring spot of the developed system, over which a measurement is averaged, these differences to plates hardly affect the measurement results. The determined color values and their standard deviation are comparable with a benchtop spectrometer (**Fig. 5**). Also, the cycle times as well as the measured amount of bulk material are consistent over several measuring cycles. This ensures accurate and precise measurements close to the process.

## Conclusion and Outlook

The continuous measurement of color during a production process is useful to improve the quality of the process and its resulting product. While laboratory analysis is suitable for color formulation, it is less suitable for ongoing process control. A prototype developed by ColorLite and SKZ enables in-process rapid determination of the color of bulk materials. The prototype can be used for inline, online and atline measurements. Due to the flexible design, incoming goods and product inspections are possible.

In addition to color control, temperature monitoring also plays an important role due to the thermochromism of some colorants. Previous investigations have shown that it is possible to calculate the thermochromic behavior of samples [4]. By compensating for thermochromism, very accurate color values can be recorded during operation. Based on the values, timely measures can be taken to prevent contamination of a batch.

The prototype developed provides a flexible solution for automatic and in-process control of color. The time delay between sampling and measurement is only a few minutes. Therefore, it is possible to react immediately to process variations and thus minimize scrap. Since no sample preparation is required, measurements can be carried out at short intervals. In addition, the automated measurement and the specially developed software prevent operator errors. ColorLite is currently transferring the prototype into a market-ready device. ■

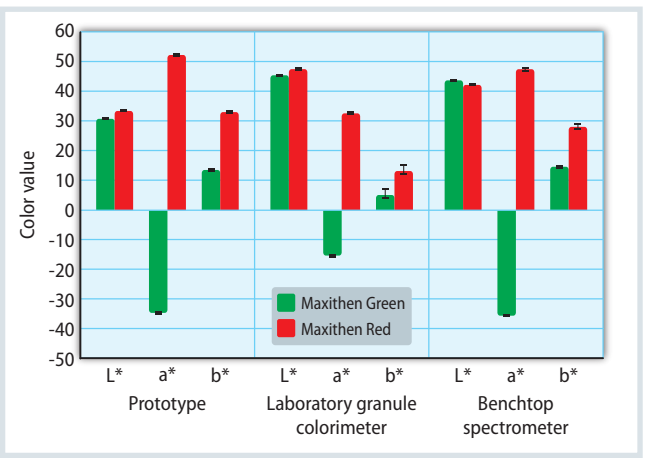


**Fig. 5.** Comparison of the L*, a*, b* values of the developed prototype with different measuring devices on the two materials Maxithen Green and Maxithen Red: the prototype measures similar values as the benchtop spectrometer. Source: SKZ; graphic: © Hanser