"InSpectro X" Inline process monitoring directly in extrusion processes by measuring the UV-VIS spectrum of molten polymers

Color values not only are an indicator for product quality but also useful as an excellent insight for process monitoring in the extrusion stage. All parameters in the production process (temperature, pressure, production speed, feeders, pumps etc.) have an impact directly on the color values. It is now possible to make measurements directly in the melt without the need for sampling. Immediate adjustments of the process parameters are therefore possible through immediate 'off-specification' detection.

Introduction

Color measurement is a well accepted technology to check the quality of the color values in the production process. Usually these measurements are performed 'off-line'.

The typical procedure for off-line measurements:

- Manually take a sample from the process
- Send/take the sample to the laboratory
- Shape the material into a measurable sample i.e. a sheet or a plate/chip
- Allow the sample to cool to room temperature
- 'Offline' measurement with a lab spectrophotometer
- Report the results to production
- Make a decision then on a process adjustment
- Repeat the above six steps, if necessary to obtain another measurement e.g. color corrections or after change of process parameters

The time between sampling and obtaining the results from the laboratory can take several hours. A significant disadvantage is that only a single measurement is generated in this time period and the quality of the color during before and after the sampling point is unknown.

With the inline color measurements taking place directly in the melt is not only complete documentation possible, but when color variations occur, immediate intervention can take place. This method eliminates the first 6 steps of the previous offline method and the measured results are available real time.

Innovation

The "InSpectro X" technology deploys a probe directly in the extruder. The Reflection Polymer Melt Probe (RPMP, fig. 1) is installed on the exit of the extruder by using ½"-20 UNF thread (typ. Dynisco®). As illustrated in fig. 2, it is screwed into position on the exit of the extruder. The RPMP consists of the threaded sleeve and fiber optics. The sapphire lens on the tip of the probe is the observation window and is very well suited to the harsh conditions in the extruder (temperature, pressure, and friction through flowing material).

Fig. 1: RPMP with sapphire window and typ. Dynisco® ½"-20 UNF - probe is made for 200 bar and 350 °C

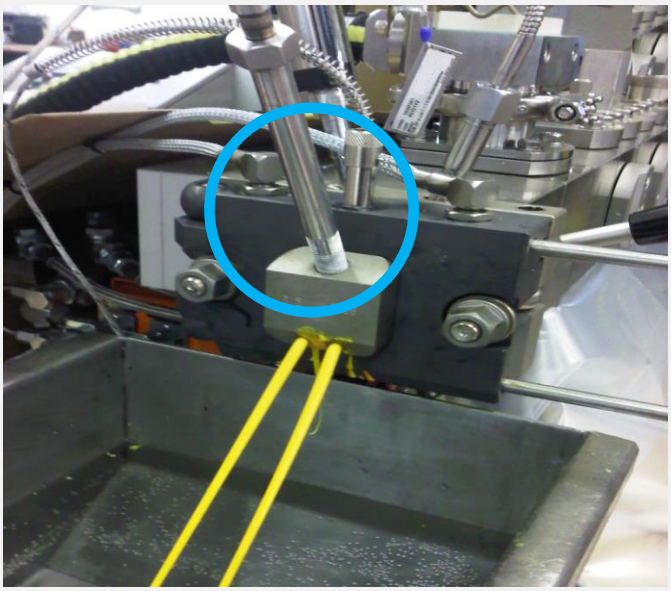

Fig. 2: RPMP in the extruder die-plate

The melt stream must completely cover the sapphire surface. The self-cleaning function of the sapphire is ensured by the shear force of the material flow. Ideal installation is directly into the melt stream at the die-plate, in an adapter or flange. Measurements are performed on opaque as well on transparent materials.

UV-VIS spectrum with "InSpectro X"

Illumination of the molten material through the sapphire window is achieved by 6 circumferentially positioned glass fibers which convey the light of a Xenon flash lamp. The reflection from the illuminated surface is detected by one centre positioned fiber optic. The reflected light is then interpreted by the spectrophotometer. Color values such as L*, a*, b* C*, h are calculated from this spectral curve (for the range of 380 through 780 nm), and displayed as trend charts, fig. 3.

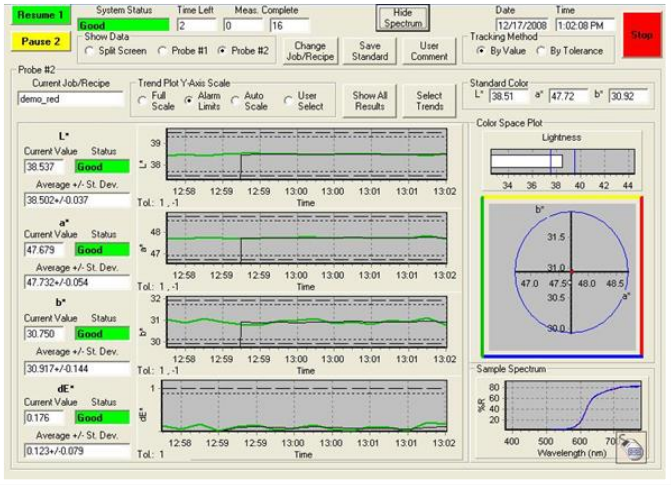

Fig. 3: Trend charts for e.g. L, a*, b*, C*, h, dE*, YI, WI etc.*

The frequency of the measurements (sampling) is freely adjustable (2 measurements/sec used for example for resident time studies). For a continuous process monitoring in the extrusion, measurement intervals are set free depending on the process needs. For mixer applications and residence time determinations we recommend shorter measuring intervals.

The calibration of the spectrophotometer is designed specifically for the demands of the production process. Measurements can be taken without interruption of the process during calibration.

Fig. 4: "InSpectro X" with touch-screen

Available interfaces:
- *OPC UA/DA,*
- *Modbus RTU,*
- *Analog (A/V),*
- *USB and*
- *Ethernet*

The UV-VIS spectrophotometer "InSpectro X" is integrated in a NEMA4 box (equal to IP55) with a panel PC and touch-screen (fig. 4). The appropriate spectral range is 220 through 820 nm (resolution 1 nm). "InSpectro X" comes in a stainless steel box, designed and equipped specifically for this application in the production environment where the ambient conditions can be dusty, vary in temperature, subject to vibration etc. The box also contains a thermoelectric cooling and heating device to eliminate the influences from ambient temperature by keeping the temperature inside the box at a constant level.

Process monitoring directly in extruders

Extrusion is a very complex process subject to influence by various factors. Such factors can be process parameters e.g. temperature, pressure, production speed, etc. the extruder and its components i.e. pumps, feeders, blenders, combination of the screws, cooling, vacuum etc. In addition, raw material can influence the result, reflecting different lots, ratio of mixture etc. All these factors, either singly or in combination result in modification to the color of the produced material during the extrusion process.

User benefits of "Sampling vs. Inline"

- ***Real-time information** about **process stability** & **quality***
- ***Impact of speed changes** on the quality of the extrusion*
- *Determination of **optimal extruder screw configuration***
- ***Innovative residence time measurement and analysis***
- ***Controlled color changes:** start phase, end of run*
- *Detection of **pulsing pumps***
- *Avoid **off-specification batches & waste** production*
- *Detection of **dosage elevations***
- *Detection of **specific recipe components e.g. additives***
- ***Optimized recipe formulation & processes design***
- *Comprehensive quality audit trail **customer documentation** of the quality of the delivered product*
- ***Reduced costs - higher ROI***

Please contact us for further information and a conversation around your needs.

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