

## ColorControl

# Color Measurement of Granules

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### Initial Situation

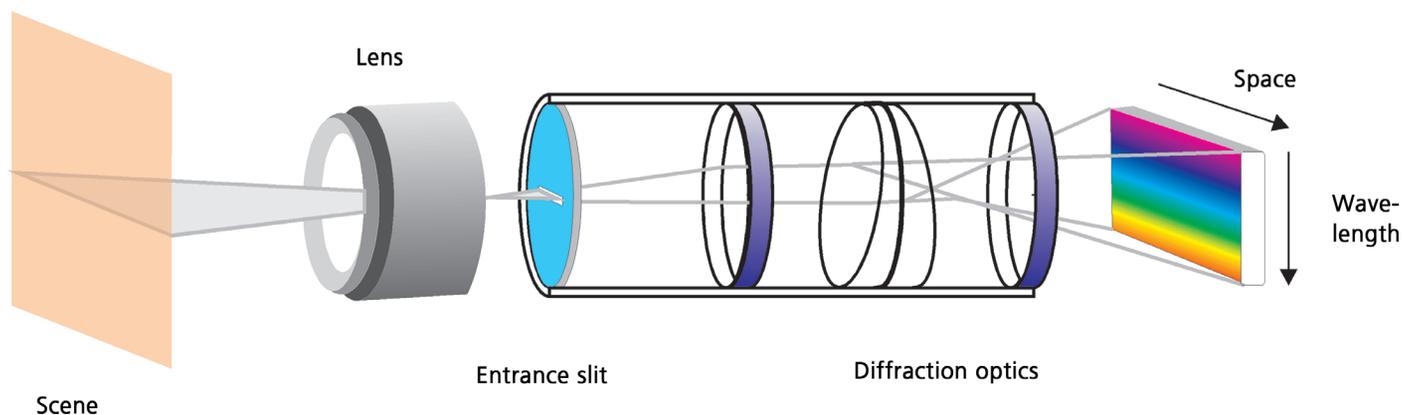
Color consistency is a feature of high quality products, a fact which is especially true in plastics manufacturing. During the compounding process, pigments are added to the molten raw mixture following a specific recipe to add color to the plastic before it is extruded and granulated. Even though specific recipes are used, it is not guaranteed that the desired color will be obtained.

The current method used for checking the color is for the manufacturer to inject mold disks from the granules, which are then measured using a conventional spectrometer. There is a relatively long time lag from taking the sample (of granules) until the results of the measurement (of the disk) are available. During this time the production plant is running continuously, possibly producing scrap.

### Problem

If the difference between the desired color and the actual color is known the recipe can be adjusted as necessary. The measurement of the color difference can, in principle, be performed at a number of points in the production process, such as in the plastic's molten phase, of the extruded plastic, of the granules or of disks made especially for measurement. Measurement of the granule is the most desirable.

If measurement is possible at this stage, the time-consuming production of the disks used for measurement is no longer necessary and the data required for correction of the recipe is available faster.



## Description of the System

The problem with measuring the color of the granules is that the surface of the test specimens is neither flat nor uniform in color. The color may be inhomogeneous due to the differing surface properties of the slice planes and the lateral surfaces of the granules, for example, or as a result of white fracture, or merely due to color variation in shaded or peripheral regions. The figure at the bottom shows the layout of the **ColorControl** system. The granules are distributed on an illuminated sliding-table that is in motion. The illumination is provided indirectly by a hemisphere (integrating sphere) with diffuse light. An imaging spectrometer is used as the sensor, see figure above.

From the user's point of view, an imaging spectrometer is a line-scan camera, in this case with 680 pixels per line. However, in contrast to a grayscale camera, this camera does not just measure one value for each pixel, but 60 color values, distributed across the visible spectrum. Each color value represents the energy of the light measured in a portion of the spectrum approx. 5 nm wide.

The images are captured line by line synchronized with the motion of the sliding-table. In the image captured the surfaces of the granules are essentially independent of the angle of the surfaces and consistent in color due to the use of diffuse light, whereas the background, the slice planes, white fracture, shadows and peripheral regions are different in color.

The measuring field and the spatial resolution are selected such that an image of a few hundred granules is made and such that there are approx. 1000 pixels per granule. Not all of the pixels in the measuring field belong to the granules and not all of the pixels on the granules provide reliable information about the color of the plastic, e.g. areas with stress whitening, the slice planes of the granules or boundary points. For this reason, only those pixels that provide reliable color information are used. The figure on the first page shows a section of an image taken of orange colored granules. The figure next to it shows the same section, except that here the pixels used for averaging have been highlighted in yellow. Upstream calibration of the system is used to compensate for the effect of longterm drift in the camera and the lighting.

Using the averaged remission spectrum the color of the granules is determined precisely and the absolute color values of the sample and any difference between the desired color and the actual color can be calculated.

## Result

**ColorControl**, a system for direct measurement of color difference in plastics manufacturing using granules, was developed in cooperation with ROC GmbH (Münster, Germany).

The system has been tested thoroughly with a large number of laboratory test series, demonstrating the reproducibility of the measurements. Several **ColorControl** systems are now already in industrial use.

## Technical Specifications

Spectral measuring range:	400 – 700 nm
Spectral resolution:	5 nm
Field of view width,length:	50, 440 mm
Spatial resolution:	80 µm
Measurement duration:	approx. 2 minutes
Smallest measurable color deviation:	approx. 0.1 %

