Technical Note 139

Measurement of Suspended Solids

Introduction

Suspended solids concentrations can be an important performance parameter for monitoring applications such as industrial process streams and sludges at waste water treatment plants. Standard methods of analysing suspended solids, e.g. EPA 160.2 or ISO 11923, require the use of a gravimetric procedure. These involve passing the sample through a glass fibre filter and drying to constant weight. This can give very accurate results but is time consuming and cannot be carried out on-line, so is not ideally suited to measuring process streams which can change quickly.

Scattered Light

An alternative approach, that is suitable for continuous monitoring, is to measure the amount of light that is scattered or transmitted by the sample. Measuring optical properties allows the rapid measurement of the level of suspended solids in a sample. The SoliSense® sensor uses scattered light for measurements. Light is scattered in all directions by solids in the sample, the proportion scattered in different directions is related to the nature of the solids being measured, notably, the particle size of the solid has a large effect on the scattering behaviour. Small particles (<0.06µm ≈ 1/10th wavelength of light) scatter light equally in all directions, medium particles (>0.15µm ≈ 1/4th wavelength of light) scatter light more in the forward direction, due to additive interference, and large particles (>0.6µm ≈ wavelength of light) scatter significantly more light in the forward direction. The scatter behaviour will also be affected by the colour (affecting the absorption of the illuminating light) refractive index and the particle shape, with spherical shapes causing more forward scatter than rod and coiled shapes.

SoliSense®

The SoliSense® measures suspended solids concentrations by making a backscatter measurement. The sample is illuminated with an 860 nm wavelength LED and the scattered light is detected by two detectors positioned at >90° to the incident angle of the illuminating light. The major advantage of measuring backscatter compared to other possible optical measurements is the reduced measurement path lengths that are needed. This is a benefit because, whilst the amount of scattered light increases with the concentration of suspended solids, eventually attenuation of the light signal starts to dominate and the response falls. This gives rise to the characteristic output of a scattered light detector like that shown in Figure 1. The solids concentrations that the peak occurs at, and ultimately the sensor goes blind at, are related to the path length. The use of backscatter detectors, that offer the shortest possible path lengths allow for the position of the peak response (the point at which the sensor goes blind) to occur at high solids concentrations. The use of an 860 nm light source in the SoliSense® reduces the effect of particle colour on measurements compared to the use of white or visible light sources.

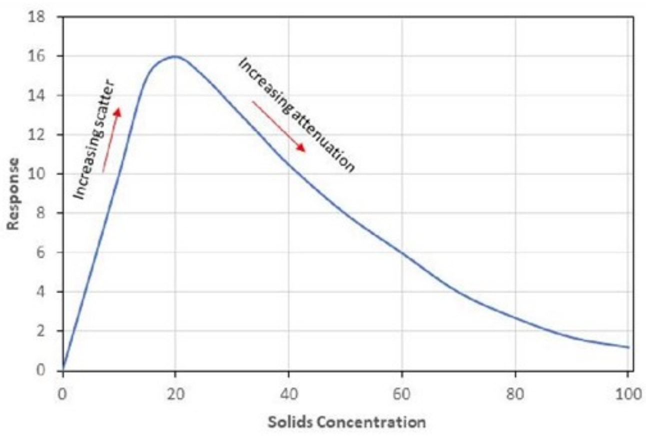

Fig. 1 Response of an optical detector to scattered light.

The SoliSense® is fitted with two backscatter detectors to maximise sensitivity and range. These detectors are located at different distances from the emitter and are known as the long and short detectors, as shown in the schematic diagram in Figure 2. The long detector, with a longer path length, offers the better sensitivity and the short detector, with a short path length offers a wider range. Figure 3 shows how the different detectors respond whilst monitoring kaolin samples.

Measurement Procedure

When an optical measurement is made to determine the suspended solids concentration of a sample, the signal produced by the detector has two components; the first is from the scattered light due to the particles in the water and the second, a background signal. The background signal will include any electrical offsets but can also include light that is not due to particulate scatter, such as ambient light or light reflected from surfaces. In samples with a high concentration of particles the background effect is negligible, but at low levels the background signal can be significant. The effect of background light variation becomes more significant if there is a difference between the background light when a calibration is made and when a measurement is made. With the SoliSense®, background light effects are eliminated due to the use of Pi's innovative measurement procedure. This procedure involves the sensor taking measurements at different emitted light levels (100% light, 75% light, 50% light and 25% light) and using the gradient between the readings to determine the sample suspended solids concentration. As the readings are taken in rapid succession the backgrounds can be assumed to be identical, so the gradient is not affected by the background light level.

Calibration

The measurement procedure means that a '0' mg/L sample is not required for calibration. This eliminates one of the largest potential errors when calibrating optical measurement instruments as such a sample is difficult to obtain, particularly on site, and the measurement of such a sample will be significantly affected by the background light levels.

For many applications only a single calibration sample is needed but for samples with high solids concentrations the detector response may become non-linear with increasing solids concentration. To allow the SoliSense® to work with such samples, multipoint calibrations (with up to 5 points) can be carried out. For each calibration sample the gradient between the signals measured at the different light levels is calculated. The gradients for the different calibration samples are used to produce a calibration curve such as that shown in Figure 4.

The use of a multipoint calibration curve allows the SoliSense® to give a linear output over the calibration range, as shown in Figure 5, which shows the readings produced with a variety of kaolin samples.

The SoliSense® probe provides fast, reliable and accurate suspended solids readings.

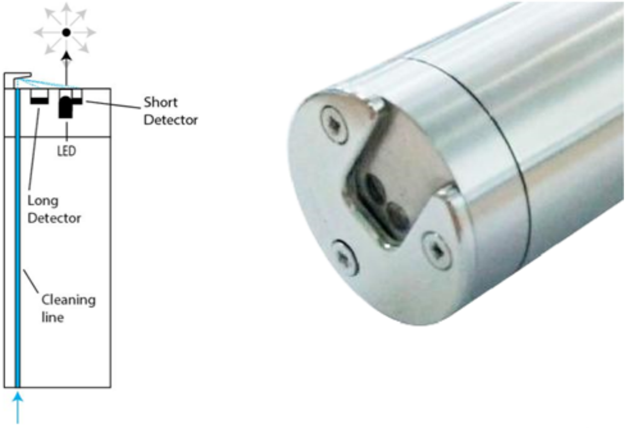

Fig. 2 Schematic diagram and picture of SoliSense® probe.

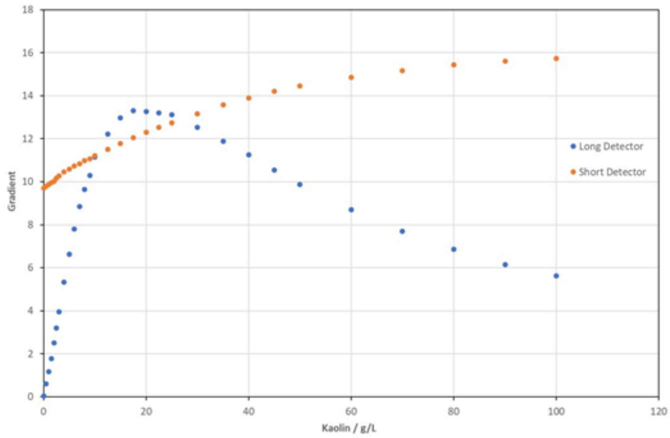

Fig. 3 Response of a SoliSense® sensor to kaolin samples.

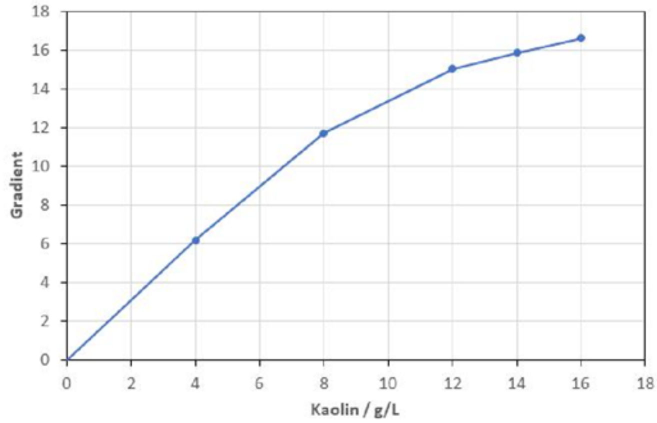

Fig. 4 Five-point SoliSense® calibration graph for kaolin.

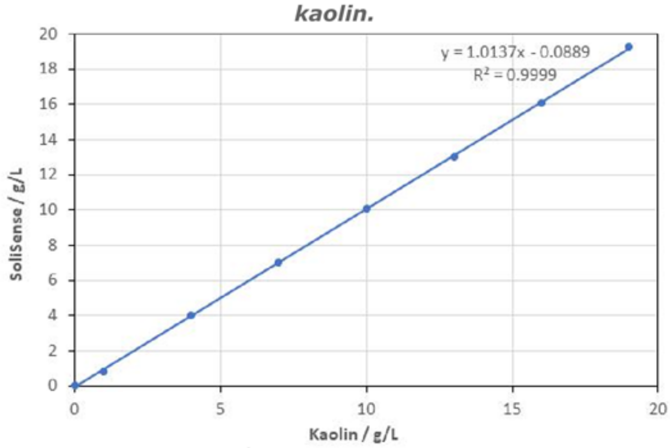

Fig. 5 SoliSense® readings for a range of kaolin samples.