MOISTURE MEASUREMENT WITH THE ELECTRIC FIELD PERTURBATION SENSOR

Technology Summary

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1.0 Introduction

Mohr and Associates, Inc., manufactures the Electric Field Perturbation (EFP) sensor system. The EFP system consists of specialized probes and associated signal processing electronics (Figure 1). The EFP sensor system, which is based on proprietary technology, measures the perturbation of a sensor probe's characteristic electric field by its surrounding environment. For a cross-channel type probe, which has probe elements on both sides of a target, this amounts to non-destructive, volumetric measurement of the internal volume of the target. A computer model of this phenomenon is shown in Figure 2.

EFP sensor systems have largely been employed in the measurement of void (air or steam) fraction in two phase flow regimes because they exhibit rapid data acquisition (500-1000 Hz or more), excellent sensitivity to variations in the distribution of water, and have a robust performance record in extreme environments.

Over the past several years, Mohr and Associates has improved and miniaturized the EFP sensor electronics,

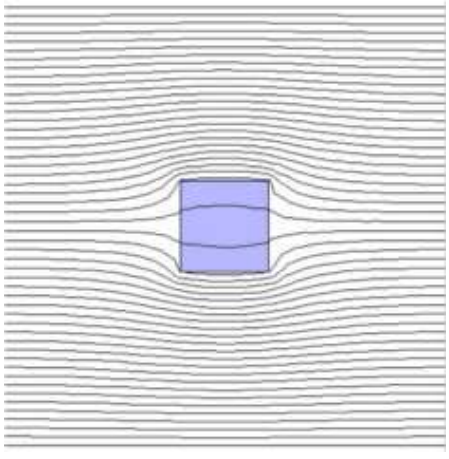

Figure 2 — Computer model representing an EFP probe's electric field interrogating the interior of a water target.

Figure 1 — An EFP signal processor box capable of handling 5 separate sensor channels. EFP signal processors are scalable over an Ethernet network.

bringing down costs more than 75%, and developed EFP probe technology that allows for real-time, non-destructive, volumetric moisture measurement in solids. This article briefly describes aspects of EFP moisture sensor technology.

2.0 Measurement of Moisture in Solids

EFP moisture sensor technology can be used with many products that require accurate volumetric moisture measurement, including those products that specifically require continuous real-time monitoring on a production or processing line. The use of this technology has been experimentally verified in a number of solid media.

Two examples are discussed below: a generic example involving sponges, and a specific application involving processing line measurement of cut potatoes. These help to illustrate some general principles in the application of EFP moisture sensor technology.

2.1 Generic Solids Example — Sponges

A generic example of a solid material containing variable amounts of water is the sponge. For illustrative purposes, a simple experiment was carried out in which a single large-volume probe was used to interrogate a bulk sample of common kitchen sponges at

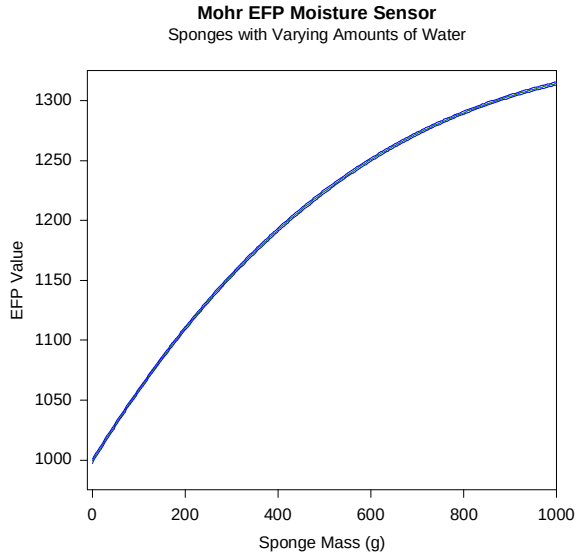

Figure 3 — EFP measurement of a bulk sample of sponges at various levels of wetness. The non-linearity is due to a layering-out effect of water as the sponges become full. This effect is unusual in food products, but can be avoided by using another probe geometry or a second orthogonal probe.

varying levels of wetness as assessed through weight measurements. The EFP measurements were non-destructive and performed in real-time. Figure 3 represents the EFP sensor measurement of increasing amounts of water stored in a bulk sample of sponges.

The agreement between the EFP sensor and weight measurement is very good. Note that the sponges show a non-linear response as they become saturated and begin to have an asymmetric distribution of water. That is, there was significantly more water near one probe element than the other. Such an effect will not be observed in most applications. However, for unusual applications similar to this experiment, another probe geometry or a second opposing probe should be used to correct for a non-homogeneous distribution of water.

2.2 Specific Solids Example — Cut Potatoes

In late 2000, the regional agricultural research division of a national corporation approached Mohr and Associates with the goal of adapting EFP sensor technology to the measurement of moisture in fresh cut potatoes. There was particular interest in measuring moisture non-destructively and in real-time at several stages in a fresh cut potato processing line.

This measurement would then be used early in the processing line to predict optimal dryer settings and later to provide feedback information for fine-tuning dryer control.

Infrared (IR) measurements had been tried with little success. This was presumably due to the case-hardening effect produced by the differential drying of the cut potatoes in the dryers. The standard method of manual oven-drying measurement, while accurate, was too slow and cumbersome to maintain proper control of moisture in the finished product.

In response to this need, Mohr and Associates developed EFP sensor technology suitable for non-destructive, real-time moisture measurement of potatoes and other food products. This moisture sensor technology is suitable for production line measurements. Further, because the EFP sensor technology produces volumetric measurements rather than surface measurements, it is not affected by the case-hardening effect in potatoes and other solids.

Figure 4 represents the EFP sensor system's sensitivity to moisture during testing at a regional potato-processing research plant. Several bulk samples of potatoes were taken from the processing line at various stages of drying; note the excellent sensitivity of the EFP sensor system in the 70-80% moisture range, which is of particular interest in the potato industry.

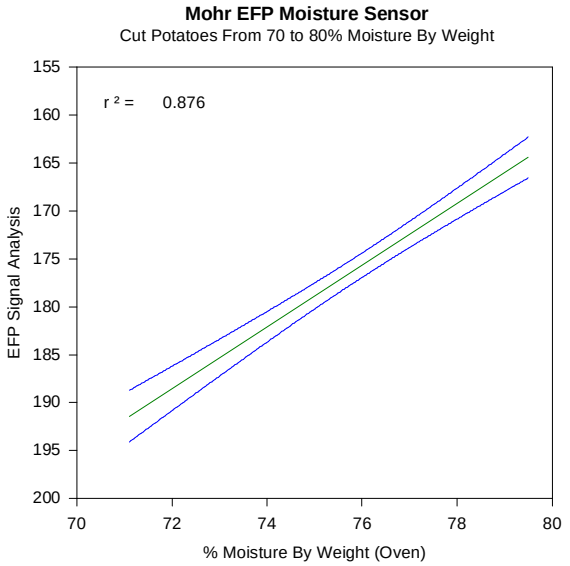

Figure 4 — Multiple bulk samples of fresh cut potatoes taken from the processing line at various stages of the drying process. The EFP moisture sensor performs very well in this important moisture range even with single measurements from many different bulk samples.

It is important to note that Figure 4 represents single measurements taken of multiple bulk samples. In contrast, process line installations gather continuous 500 to 1000 Hz measurements in real-time. This corrects for any random changes in target sample geometry that may occur and results in further refinement of results.

3.0 Conclusion

Mohr and Associates' EFP moisture sensor technology is a recent addition to the process control engineer's toolkit, allowing accurate volumetric, non-invasive moisture measurement in real-time. It is particularly well-suited for applications where moisture control is essential for product quality control.

4.0 EFP Moisture Sensor Specifications

Sampling volume: customizable

Sampling rate: 500-1000 Hz

Moisture range: 0-100%

Moisture sensitivity: ± 1% by weight or better

Multiple configurations available:
Single channel
Multiple channel

Communications: 10/100 Mb Ethernet, analog

Data acquisition: basic DAQ software included; most 3rd-party data acquisition environments, such as LabVIEW, also work.

5.0 Pricing and Availability

Please contact us for the latest pricing and availability.

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