

# New Capacitance Electronics Technology For Maintaining Slot Die Coater Gap Uniformity in the Lab and in Production

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## **Extended Abstract**

Introduction of a variety of system improvements made on the Slot Die Coater Gap Uniformity Measurement system since the technology was introduced at the 2004 ISCST Conference. These improvements will include: more compact and higher precision capacitive stand alone gap measurement electronics package, thinner and higher temperature gap sensor wands and Windows 7<sup>®</sup>, BargrafX<sup>™</sup> signal conditioning software.

The use of this technology has resulted in the possibility of achieving repeatable coater gap uniformity better than 10 micrometers (0.25 microns) across the full length of the coater. Specific examples of thin gap control currently in use by world leaders in adhesive labels, batteries, thin films and other converted materials are shown. The full system includes flexible sensor wands, special sensor positioning wand holders, and signal conditioning electronics and BargrafX<sup>™</sup> software. The presentation is of interest to personnel charged with the job of measuring micrometer repeatable gaps to control product uniformity and quality.

## **Introduction**

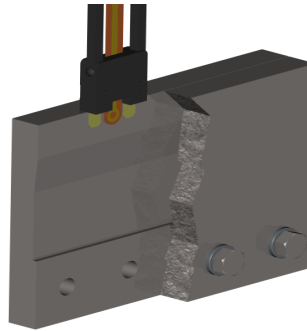
Capacitec has been working closely over the past 20 years with the leading global manufacturers of tapes and films for various commercial and industrial uses. The development was pursued directly with end users as well as with various coater suppliers. Initially, the common thread between these users is the utilization of slot extruder dies to apply an assortment of very thin chemical, adhesive and photographic coatings to a variety of media.

During the last several years several new slot die coating applications have surfaced where very thin gaps and high precision coating uniformity across the full length of the die is required. Specific examples of these new applications include:

Production of medical test media,  
Coatings on lithium ion and other new technology batteries  
Flexible solar panel coatings  
Flexible displays

In a typical application the coater die slot gap sizes range from 0.006" (150 microns) to 0.024" (600 microns) with a typical set of slots being 0.006", 0.008", 0.010", 0.012", 0.014" etc. The length of the slot gap is typically 3 to 6 feet (1 to 2 meters) wide.

Since there is a direct relationship between setting the width of the slot gap and the thickness of the coating material, it is critical for manufacturers to set a very uniform gap along the full length of the coater die. The uniformity must be held at the sub micron level. (See Figure 1)



*Figure 1: Measurement fixture in the process of measuring coater gaps*

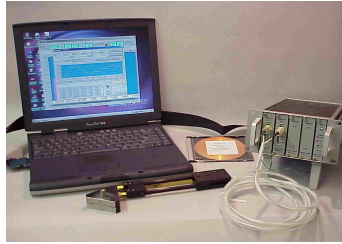
### **New Compact Electronics Package**

The current Slot Die Coater measurement system provides an electronics package with two 4100-S series capacitance amplifiers housed in a four channel 4100 series electronic rack. (see Figure 2) Aside from the larger footprint, this system requires an AC power connection and custom analog output ribbon cable connected to a PCMCIA A/D converter in the host computer.

The new Capteura® Model 200-ENC stand alone enclosure with a compact footprint of 8' x 3.5" x 1.2" (203mm x 90mm x 30mm) houses a dual channel 220-S capacitive amplifier with the optional built-in USB data acquisition card option which receives full power from the host computer (laptop). This new compact size and enhanced connections simplifies the lab version of the Slot Die Coater Gap Measurement system as well as making it significantly easier for coating engineers to package and bring the system on the road for auditing slot die coater gaps at product specific production plant locations.

Additional advantages of the Model 200 electronics package are lower signal noise, ability to withstand electrostatic discharge (20kV) to the amplifiers/sensors, improved temperature stability, improved repeatability and lower power consumption plus compatibility with existing sensors/wand holders.

As was the case with the 4004 electronic rack, the new electronics combined with special features in the Bargrafx software results in the system only requiring two channels of electronics versus 12 channels to drive 6 different dual sensor gap measurement wands. The new compact package does not however support the switching style electronic cards for the GPD-2 150 micron dual switching symmetric sensor wand option.



*Before: 4 channel rack with AC power and custom analog output ribbon cable*



*After: 2 channel enclosure with USB power/data output*

*Figure 2: Comparison of electronic packages*

### **Sensor Wand Selection**

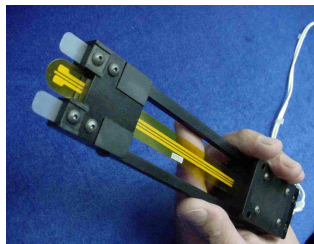
The capacitive sensors are attached back-to-back on a sensor wand. The configuration, thickness and material of the sensor wand depend on the application at hand. In the past several years Capacitec has developed new sensor wand technology resulting in thinner wands and high temperature capability.

Users in the medical field have successfully qualified model GPD-(3x1)-I-A-75 very thin tandem dual sensor wand with a custom wand holder and reduced 2.95" (75mm) length to repeatably measure slot die coater gaps to down to 0.0041" (105 microns).

A new high temperature E series flexible wand can measure extruder lip gaps at constant operating temperatures of 250°C. It functions the same as standard dual sensor wands except it opens up new possibilities for use in considerably hotter extrusion and coating die processes. Currently there are no electronic gap gauging tools to confirm gap sizes in adjustable extruder dies operating at 250°C.

### **Custom Fixtures**

An additional discovery uncovered during the design process was the importance of wand positioning when taking gap measurements. The best measurements were attained when the sensor wand was held stable in a parallel position relative to the two halves of the coater die. When the wand was allowed to twist or rock out of this position, accuracy and repeatability would deteriorate. In order to assure best-case parallelism between the sensor wand and the die slot, a special custom fixture was designed. (See Figure 3)



*Figure 3: Adjustable Custom wand holder/positioner*

### **Bargrafx Software**

The Capacitec Bargrafx™ program was developed under National Instruments' LabView program. It now runs on Windows 7®. It has a real-time Calibration module which takes analog output voltage and turns it into linear engineering units using polynomial interpolation (to 4th degree). A general equation editor allows any linearized channel to be added, subtracted, multiplied or divided from any other linearized channel. Additional features are an equation editor, a limits module that allows the assigned bar graph display to reflect upper and lower limits and a data output feature with standard .txt store-to data file format.

### **New Gapman® Gen3 for Production Set up Applications**

For users that would like the option of a simpler set up tool in production versus lab locations requiring a laptop, Capacitec has redesigned the current Gapmaster3 semi portable shop floor system with a recently developed fully portable Gapman® Gen3. The main design enhancements of the Gapman® Gen3 are accuracy of 0.5 μm and resolution of 0.1 μm for a 250 μm full scale gap range. It offers 10,000 data point logging and storage capabilities, 22 hour life, and a simple PC user interface. It is light weight (400 grams), fully portable using 3 AAA batteries and has a rugged enclosure. The Gapman® Gen3 records and stores data points for easy transfer to SPC, in support of Six Sigma and other quality systems. An industry standard USB Type A port combines data output and external power. The data files are a .CSV file structure for simple import into Microsoft Excel®. The portable Gapman® Gen3 non-contact gap measurement system can also replace feeler gauges as a set up tool in the measurement of extruder die gaps. See Figure 4.



*Figure 4: Fully portable Gapman® Gen3*