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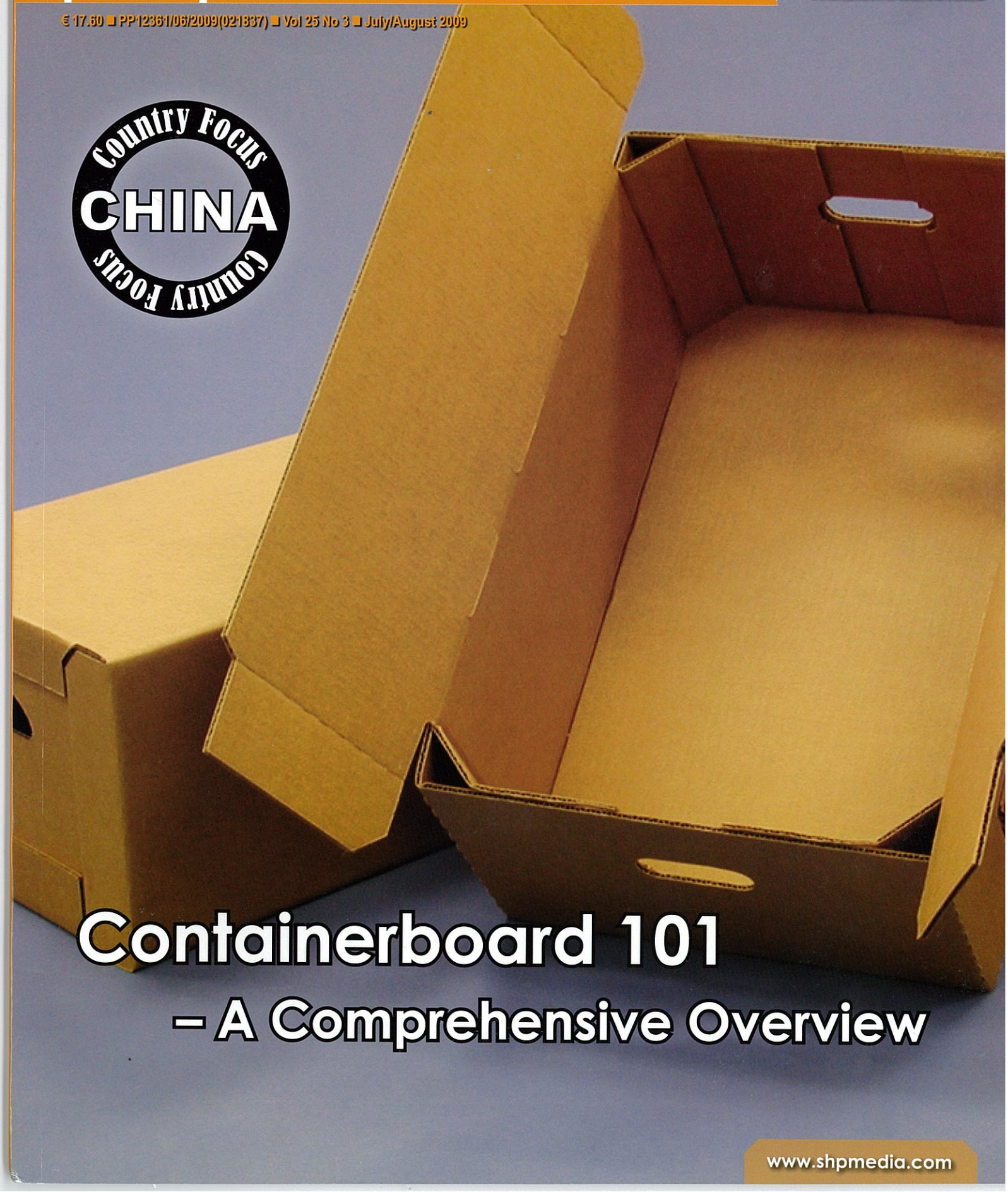

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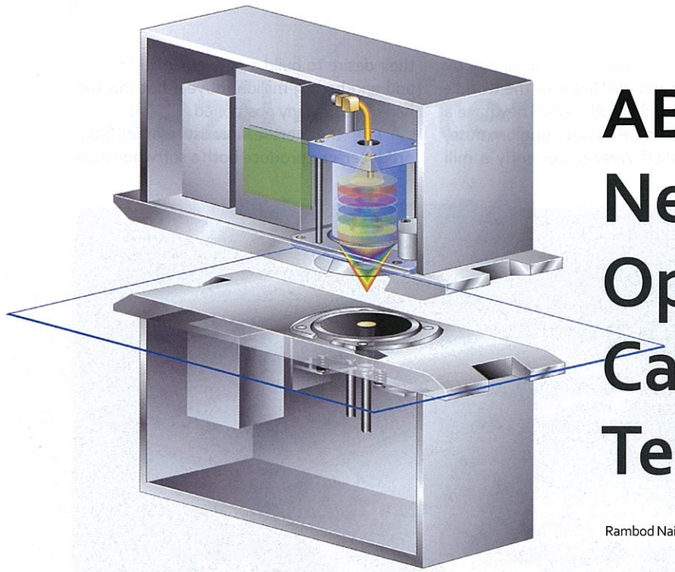

ABB Introduces Next Generation Optical Caliper Sensor Technology

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Caliper measurement and control is a vital part of papermaking. But this measurement can be a challenge. Over the years, various mechanical and optical sensors have been invented to achieve the best combination of accuracy, no sheet damage and reliable operation. Traditionally, this has been achieved through the use of dual-sided, contacting caliper sensors. But some paper applications pose tremendous challenges for the contacting caliper skis.

QCS suppliers have been, in the last few years, focusing on caliper sensors based on the laser triangulation technique. This method, however, has its own problems in obtaining a consistent and accurate measurement

ABB has introduced a new optical on-line measurement that measures caliper without two-sided contact of the sheet and without laser triangulation and its inherent inaccuracies. The new sensor uses a different optical approach which provides greatly improved measurement accuracy and stability. The new Optical Caliper Sensor is based on a confocal displacement technique. The sensor is ideal for applications where the sliding skis of traditional caliper sensors gives rise to problems.

This new sensor, the latest in ABB's 50-year history of pioneering on-line paper quality measurements, finally provides papermakers with the precision tool to measure and control caliper even for some quite demanding paper grades.

Limitations of Laser Triangulation

Considerable effort has been invested over the past decade to develop a single- or dual-sided non-contacting caliper sensor applicable to the paper industry. To date, much of this effort concentrated on laser triangulation displacement sensors. The triangulation works by focusing a laser beam onto the surface being measured and detecting the reflected light via an imaging sensor located at an oblique angle to the laser (see Error! Reference source not found.).

This method works extremely well for surfaces that have no penetration issues such as metals. However, if the light penetrates into the bulk material, as is the case with paper, then the method will have difficulties determining the true surface location and hence give a false distance measurement.

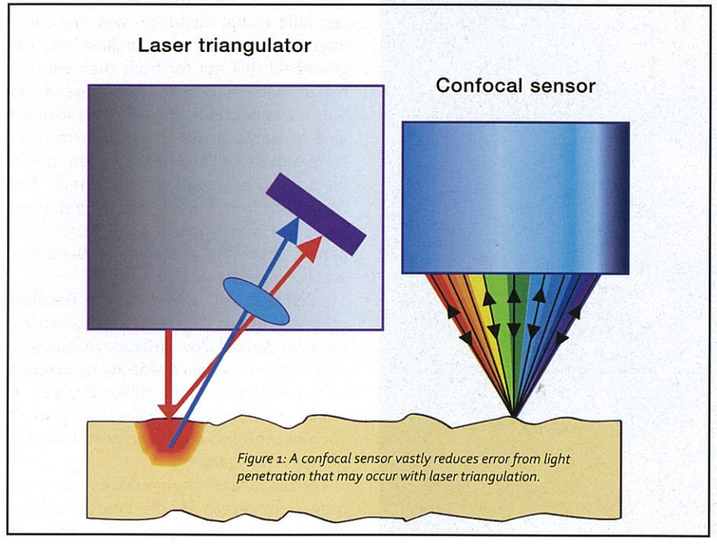

Figure 1: A confocal sensor vastly reduces error from light penetration that may occur with laser triangulation.

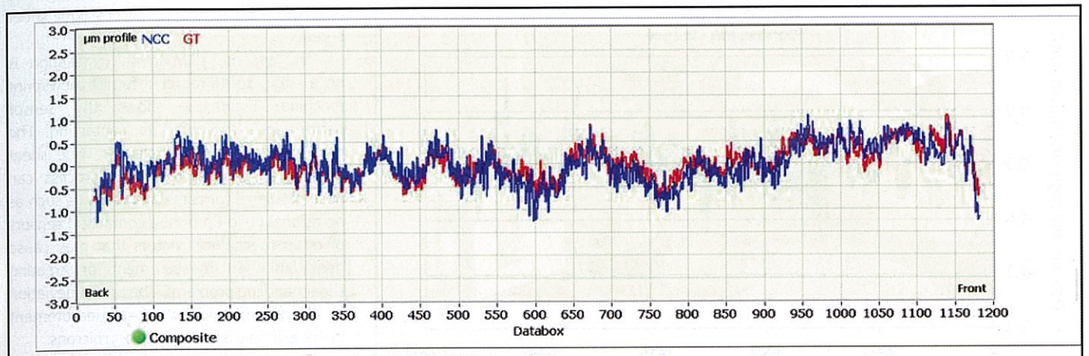

Figure 3: On-line high resolution composite profiles on dual-side coated LWC paper.

Indeed, this was observed when ABB built and tested our first laser triangulation caliper sensors in the 1990s. One of the key observations made was the need to calibrate the sensor according to paper type. In our own testing comparing laser triangulation and contacting measurement on different paper grades, deviations up to 40 microns were observed. For some cases on thin paper grades, the corresponding laser sensor caliper errors can approach 50% of the sheet thickness. The light scattering and penetration issue has also been verified by other researchers [ ],[ ],[ ].

Since the sheet properties will also vary to some degree while in-grade, this implies a risk of unstable measurement or profile errors in a paper production run. This is because the light penetration error depends on process conditions that may change. This includes for instance, fiber type, fiber length, fillers and coating amount and constituents, calendering line pressure profile, and more.

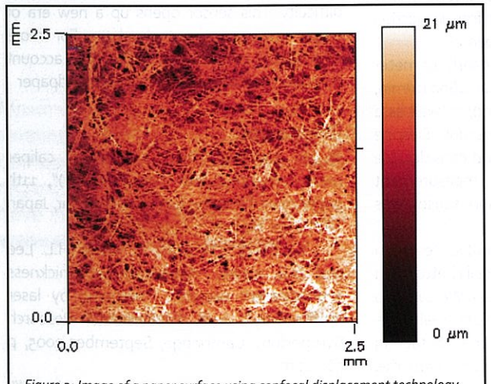

Figure 2: Image of a paper surface using confocal displacement technology employed in the Confocal Optical Caliper Sensor

Because of these problems laser-based sensors may require special grade to grade calibration and periodic re-tuning, or different corrections across the profile.

Next Generation of Optical Caliper Technology

The optics approach for our Optical Caliper Sensor is based on a confocal

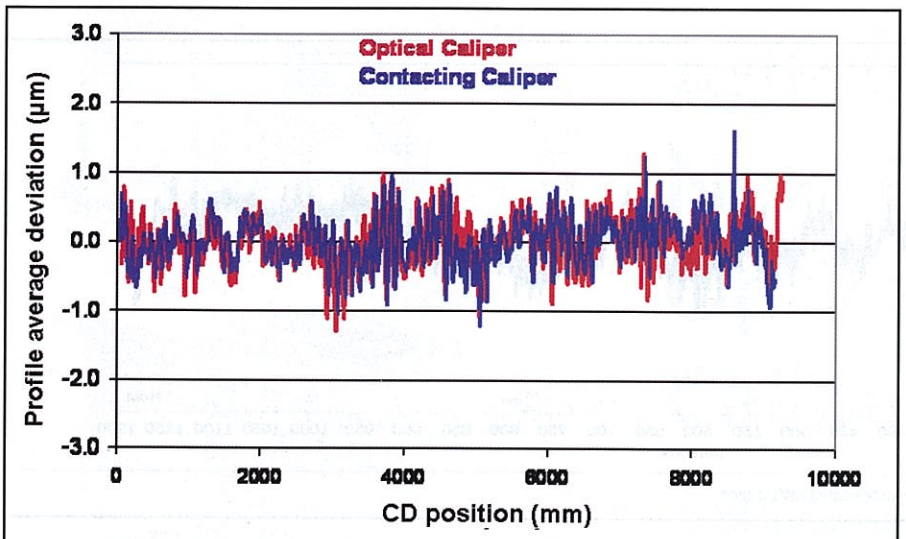

Figure 4: On-line performance on fully-recycled newsprint grade.

displacement method (see Figure). The term "confocal" implies that one very small spot of the surface is in sharp focus for both source and detector by a shared lens and fiber optics delivery.

The measurement system analyzes the reflected light and the maximum detection peak is due to the light from the top surface, while all other reflections are out of focus and not detected. This technology has made recent advances for applications in microscopy, thin-film research and semiconductor manufacturing. It has also been demonstrated in research facilities for study of sub-µm paper surface topography.

As a result, this Optical Caliper Sensor senses the true paper surface, thereby vastly reducing the light penetration errors typical of laser-based caliper sensors (see Figure).

Figure shows a topographical image of paper taken by the confocal displacement technology. It is apparent that individual fibers are always detected clearly and in sharp focus. The fiber translucency and related light penetration is not a problem for this technology.

A well-controlled sheet position is essential for any optical caliper measurement. The sheet in this sensor is positioned accurately and kept very flat by means of a sheet stabilizer in one sensor head. The stabilizer contains the optical target where the optics is focused. The sheet control is achieved by means of dual concentric rings with a very light vacuum. This will gently stretch the sheet and remove any wrinkles in the optical measurement zone. Super-smooth ceramic coatings and hard materials are used in the sheet stabilizer plate to prevent build-up and sheet marking, and to provide excellent wear resistance. The large vacuum zones are designed to prevent accumulation of fillers and coating and reduce or eliminate the need for maintenance cleaning. without marking the sheet or allowing build-up of coating or contaminants. As a result, the Optical Caliper sensor is applicable to demanding grades such as newsprint, coated, super calendered, and fully-recycled grades.

Measurement Results

The Optical Caliper Sensor was first tested on a large, dual-side coated LWC machine. We obtained exceptional agreement with the contacting caliper sensor. Figure displays a high resolution CD profile comparison between the optical caliper (OC) and the contacting caliper sensor (GT). This profile was taken from inspection data during the test production period.

This machine produces a nearly 10 meter wide sheet running at more than 1600 m/min, with inline multi station coating, as well as a large inline gloss calendering section. Despite the high speed, a thin sheet and considerable vibration, the optical caliper measurement agreement with the contacting sensor was excellent.

It can be seen that the profile deviation between the two sensors is typically better than 0.5 microns on this LWC process. We can also see that the optical sensor detects small scale variability more clearly than the contacting sensor. One of the main concerns with this customer was potential sheet marking by the sheet stabilizer. The process was monitored daily for sheet marking. No marking was observed, due to the stabilizer's light sheet contact.

The second, permanent, installation is on a large, 100% recycled furnish newsprint machine. Figure 4 shows the sensor performance compared to contacting. The machine produces a 9.3 meter wide sheet running at 1,800 m/min. This process can pose problems for contacting sensors such as occasional build-up on the contacting sensors or other mechanical factors that may cause degradation in measurement or creating sheet handling problems. The profile deviation between contacting and optical measurement in this example is better than 0.5 microns.

The sensor has been used for CD control since mid-February, 2009. Since then, the paper maker reports improved reel building, and profile variation is reduced compared to the results from the contacting sensor. Furthermore, the sensor has proven nearly maintenance-free on this process and does not require any special cleaning or periodic adjustments. Sensor profile agreement with the customer's laboratory has also been improved, with agreement better than 1 micron and very good long term sensor stability.

A Time for Change

The new confocal principle Optical Caliper Sensor has been shown to provide a robust, reliable and very accurate caliper measurement on different and demanding process applications. As the sensor avoids some of the inherent measurement issues of laser triangulation, it provides papermakers with an improved instrument to measure caliper in processes where dual-contacting ski devices experience difficulty. This sensor opens up a new era of caliper measurement technology. For more information contact your local ABB account manager or visit www.abb.com/pulpandpaper

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